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RURAL REFLECTIONS

The influence of mechanisation upon agriculture is a matter which has been liberally commented upon in recent years. That is not surprising ; for probably in no other industry has the progress of the machine been so rapid as it has recently been in the business of farming. To-day, it is difficult to find a process in agriculture which has not been at least touched by mechanisation. A great deal of the former drudgery of farm work has been eliminated by the application of machinery, and although mechanisation has not attempted to make two blades of grass grow where one grew before, it has undoubtedly led to higher productivity in all branches of agriculture. This achievement—and it is a significant one—has resulted from the partnership of engineers and farmers.

To these and other matters related to the progress of agricultural engineering, fresh emphasis was given in the presidential address which Mr. D. R. Bomford delivered to the Institution of British Agricultural Engineers on Thursday of last week. Mr. Bomford is an engineer and a farmer and is, therefore, admirably equipped to make a useful appraisal of agricultural machinery problems from both the manufacturer's and the user's points of view. His address not only surveyed an extensive field, but contained several apposite rural reflections. Mr. Bomford recalled, for example, that the greatest factor in the change in farming which has occurred during the present century has been the coming of the machine. The farm labourer has become a skilled controller and maintainer of machinery with more scientific knowledge than was possessed by the farmer himself fifty years ago. What is perhaps even more important is that "the farmer has at his disposal the results of so much mechanical and other scientific research that he is being driven to specialisation of production because the mass of scientific knowledge applicable to a wide variety of production is more than one man can absorb." No doubt there are many engineers, and farmers, too, who would say at once that this revolution in agriculture is wholly and solely the outcome of the internal combustion engine, superseding as it has done the use of animal and steam power on the land. Beside that opinion, however, Mr. Bomford set another of equal importance. Talking about the late 1920s, when a fresh impetus to mechanised farming was beginning, he said : "the first requirement was not the internal combustion engine, but a state of mind which would make men look critically at things as they were, face the hard path of progress, and endure the setbacks and disappointments which pioneers in any progressive movement must expect." Engineers have always been pioneers. There have been so many occasions in the past when they have realised that particular processes in industries other than their own could be improved by the judicious application of machine power. That realisation has many a time inspired engineers to devise and produce new machines. Yet the full acceptance and utilisation of many a machine has not been accomplished without setbacks and disappointments. In agriculture this has certainly been, in days now past, a common experience, and all honour is due to those engineers who have steadfastly pioneered the hard road of farm mechanisation. They, in company surely, with all engineers, have understood, as Mr. Bomford aptly observed, that "mental rigidity and stagnation arise when people fail to see their way through difficulties which confront them."

Happily, there is at present no sign of stagnation in that branch of our profession which comes under the heading of agricultural engineering. It is a branch of engineering which has long since extended its bounds far beyond the restricted space of the most efficient village smithy ! The output of the manufacturing side of British agricultural engineering is now valued at about £100 million a year, and it would be by no means easy to assess the financial value of the research and development work that is being pursued. It is desirable, nevertheless, to keep an eye on the future of agricultural engineering. Mr. Bomford did not expend the whole of his excellent address in reflections upon the past and the present. He challenged the members of the Institution over which he presides about what may well be the requirements of the future. Mechanisation has been appropriately defined as the substitution of mechanical power for power provided by human or animal muscle, and Mr. Bomford believes that in every instance where machine power has been applied there is scope for its more efficient application. That is, surely, a belief which all engineers will endorse. It does, however, envisage development work of a kind which may turn out to prove far less spectacular than work related to the initial application of power, though its value, especially to the farming industry, is none the less great. In a relatively

short period of years, this country has seen animal power on the land completely displaced by machine power, and it has seen also the machine take over the more complicated processes which could once only be performed by the human hand. But for the most part, of course, the man must still be there to direct and control the machine. Mr. Bomford suggested that a future farming requirement might well be that "the machine should direct and control itself." There is much serious study of automation now taking place in other industries, and it is no mere pipe dream to believe that automation may have its place in the future of mechanised farming. The path of the pioneer in this and other directions is not likely to be an easy one, but it is a path which will undoubtedly be smoothed by the progress in agricultural engineering education that is now being so wisely advocated and promoted.

SAFETY FOR OTHERS IS SAFETY FOR ALL

One of the difficulties in preaching upon the subject of Safety in Industry is not that of finding anything fresh to say, for that is scarcely possible anyway, but that of finding in a well-worn subject fresh ways of saying it. At the Conference of the London Industrial Accident Prevention Groups in the Guildhall last Friday, some of the speakers did, indeed, manage to overcome that difficulty. But, like anyone who is actively engaged in trying to prevent accidents, they had to face the problem of attempting to make people act in some degree against their own natures. For even in this civilised age it is still true that if man is to survive he must be bold and venturesome. Courage, even if it is the most common, is also still the most essential of virtues for success in life. Yet those who set out to prevent accidents must constantly cry out "Take Care!" and "Look before you leap!" and they have to do it in the face of a belief apparently bred into everyone that disasters are things that only other people have to experience. The way, in fact, is hard. For very little can be done to change human nature. Shock tactics can, indeed, make people act more carefully—but only temporarily. The effect of Safety Weeks and horror posters soon wears off and shocks, like drugs, become less effective the more frequently they are administered. Basically, in fact, there are only two certain ways of reducing accidents. They are to make accidents almost impossible, as by the placing of guards around dangerous machinery or insisting upon the wearing of protective clothing; and to make the safer way of performing any operation also the easier method, so that there is no excuse for taking a risk. Those are ways of reducing the number of accidents that are proving effective in the factory and on the railways, in the air and at sea. If more effectively applied, they could immensely reduce accidents on the road.

But because it is necessary to take some such action to reduce accidents, because it must be accepted that, however much safety may be preached, men will often prove careless or over-venturesome, there is no need to be depressed about the effects of preaching. For—it is a very pleasant facet of human nature—though men are often careless of their own safety, they are constantly concerned about the safety of others. Older men in a factory, for example, often prove intensely critical of a management, if they observe some danger that could be avoided, not in the interest of their own safety but in that of "irresponsible" youngsters who may get hurt! One can teach until all's blue that it is unwise to step on a patch of oil; sooner or later someone will still step on it! Nor can one ensure that there never will be a patch of oil for someone to step on. But as a consequence of this quirk of human nature one effect of preaching is likely to be that the presence of the patch of oil will be reported to someone who can remove the danger. It is true, therefore, that the main means of reducing accidents must be the removal of hazards, for we do not think there is very much hope of making people appreciably more careful. But if top management shows a real interest and constantly preaches safety the hazards will be pointed out to it. Furthermore, as Sir Ewart Smith remarked at the Guildhall, this kind of co-operation between managements and men for a humanitarian purpose has excellent reflections upon works relations as a whole. Indirectly a constant outpouring of safety propaganda can lead to very significant results; but only if management proves itself willing to follow it up by taking energetic action.

THE JET FLAP

The fundamental and far-ranging paper on the "Jet Flap," presented to the Royal Aeronautical Society by Mr. I. J. Davidson, and reprinted in abstract in this and last week's issues, was followed by a discussion, extracts from which also appear in this issue. We detected in that discussion certain often recurrent and always disturbing themes. One appeared to be, not scepticism, but sheer disbelief. As it was expressed in the face not only of mathematics (which can seldom be challenged, though its assumptions can be), but also of cinematography, this disbelief seems likely to have been inspired by little more than a devotion to devils known as against those unknown. Another theme better founded and not assailed was that the paper was likely to prove the herald of a torrent of reports based on laboratory experiments, experiments that would become less than inviting as the scale of the models increased, and which would culminate in design studies for aircraft with, perhaps, only a casual likeness either to birds or conventional aerodynes. More welcome comments were those stressing the value of hitherto unattainable lift coefficients, not so much to the 500 m.p.h. projects of the paper—having made our runways, we might as well land upon them—but more particularly to the short-range carrier condemned eternally to inadequate airfields. Marked interest was expressed in a hybrid aircraft, visualised with propellers to overcome drag and a jet flap to give much more lift for the same or even lessened profile drag, and assumed able to land at a comfortable attitude allowing the pilot to see the runway. These contributors to the discussion alone, we believe, had any hope of free flight with a jet flap in the near future. For the National Gas Turbine Establishment can hardly be expected to rush into flight. Its Director has observed that his work usually takes place as much as five years before practical results are seen. Moreover, it would be understandable if official circles were determined not to build aircraft without very complete justification. Memory is still fresh of the pilotless rocket aircraft built to exceed the speed of sound: this project may have seemed a good idea at the time, but it drew calumny upon the heads of its sponsors when the Americans showed how much more rapid advance could be if piloted craft were used. An airliner capable of flying to the United States, the "Brabazon," was built, and discarded, unfortunately, before the value of a gust relieving device to protect the airframe from peak stresses in flight became unmistakable. Armstrong Whitworth built an advanced jet-propelled flying wing, but the recently appointed Technical Director of that group is not sanguine as to the prospects of boundary layer control, proven possible on that wing, being applied to commercial aircraft. A project to pioneer means of propulsion and control, both alike novel, may well not find the stars auspicious.

We cannot hold, however, that it is safe to confine ourselves to small-scale and relatively inexpensive experiments. Britain's influence on air transport is not assured; favour for the sleeve-valve engines, whose reliability was our pride, has withered, and an airline of immense experience has demonstrated its confidence that the achievements of the United States in building large military jet aircraft can be translated to civil operation. Therefore we feel no doubt that an experimental aircraft should, literally as soon as possible, be constructed, or better, modified, to fly a jet flap, taking confidence from the facts that a primitive version incorporating propellers would be safe in flight in any eventuality, even if the jet flap had to be withdrawn, and that engines suitable for supplying the flap are already in existence.

A Seven Day Journal

The Joint Iron Council

THE Joint Iron Council has issued the report of its executive committee for the year ended June 30th last. The report records a marked improvement in trade conditions, and says that in the first three months of 1955, the production of iron castings exceeded 1,000,000 tons for the first time in any quarter. The total output of iron castings in the year covered by the report was 3,865,123 tons, an increase of 5·3 per cent over the preceding year. But the report also notes that the expansion was uneven between the main sections of the industry. The output of automobile castings (excluding tractors) increased by 24 per cent, over the preceding year, and the production of engineering castings rose by 9 per cent. The output of pressure pipes increased by 2 per cent, building and domestic castings production was 4 per cent higher, but production of railway castings fell by 11 per cent. Total pig iron stocks at ironfoundries, the report adds, were fairly stable during the year, though towards the end of the year hematite stocks dropped sharply as a result of the stringency in supplies. Last Tuesday evening, the Joint Iron Council held its annual banquet at the Dorchester Hotel, London, with the president, Mr. N. P. Newman, in the chair. The principal guest was the president of the Board of Trade, Mr. Peter Thorneycroft, who proposed the toast "The Iron Industry." In the course of his speech, Mr. Thorneycroft referred to the heavy coal imports, and to the imports of steel, which this country at present found necessary. One of the greatest contributions to the economy of this country, he said, would be for the coal industry to become once again a great exporter. The president of the Council, Mr. Newman, replied, after which "The Guests" was proposed by Sir Frederick Scopes, immediate past-president, and felicitously acknowledged by Sir Hugh Beaver, chairman of the Advisory Council for Scientific and Industrial Research.

Aswan High Dam

WE learn that the Egyptian Government has appointed a British firm—Sir Alexander Gibb and Partners—as consulting engineers for the proposed high dam at Aswan, on the River Nile. Although the consultants have, only last week, been appointed, investigations had previously been carried out by an international panel of consulting engineers, and some account of the significance of the scheme, as based on their preliminary proposals, can be given. The Egyptian Government's ten-year development programme is largely centred round the scheme, about two-thirds of the programme being dependent on it. The proposed dam would be built 3½ miles upstream from the existing Aswan dam; it would provide almost complete control of the flow downstream, including long-term year-to-year storage, and would thus permit an increase in cultivable land of about 1·3 million acres, and improved irrigation in a further 1·4 million acres (the present area in Egypt, which is fully irrigated, is about 6,000,000 acres). As envisaged at present the dam would be a rockfill structure, 3 miles long and 330ft high; seven 54ft diameter river diversion tunnels would be needed for its construction, and it would form a reservoir with a capacity of about 105 million acre-feet, nearly a quarter of which would eventually be taken up by silt. Hydro-electric power would be generated initially, it is thought, from eight 60MW sets, yielding 4250 million kWh a year. The cost of the complete scheme, including irrigation and reclamation works, is at present estimated at £265 million, and an increase of £225 million a year in the Egyptian national income is expected to result from its operation. The dam would be founded on a bed of sand and silt, 650ft deep, which would require special methods of compaction and grouting to render it impermeable. The scheme is considered to give the most promising method of storage over several alternative proposals investigated, including the possibility of a series of storage dams on the Blue and White Niles.

British Standards Institution

AT the recent annual general meeting of the British Standards Institution, Sir Herbert Manzoni, engineer and surveyor of the city of Birmingham, was elected chairman of the general council. At the same meeting Sir Roger Duncalfe was re-elected president and Mr. John Ryan elected as vice-president, on completion of his three-year term of service as chairman of the general council. Sir Stanley Rawson, vice-chairman of John Brown and Co., was elected chairman of the Engineering Division Council in succession to Mr. S. J. Harley. In presenting to the meeting a review of the work of the Institution during the past year, Mr. Ryan referred to industry's increasing demands for services going beyond the mere preparation of national standards. He drew attention to the growing international efforts to secure basic alignment of national standards among the many countries now preparing them: the need to eliminate duplication and overlapping of the standards prepared for different industries; the promotion of the application of standards, and the demand for greater publicity services, both in relation to industrial and consumer goods and to home and overseas. He indicated some of the new fields in which British Standards are being prepared—those concerned with measures to deal with air pollution and to promote road safety; standards for electronic components, television, control instruments for automation, three-dimensional film equipment, &c. Much of the annual report of the Institution for the year ended March 31st last just issued, is concerned with the projects for British Standards which had been under consideration during the year by some sixty major industries, and notes are given on some of the more important standards issued. It is interesting to record that during the year under review nearly 900,000 copies of standards were sold, and that there are now some 8300 firms, associations and professional bodies subscribing to the Institution.

Annual Report on Alkali Works

THE ninety-first annual report on alkali works by the chief inspectors has been published, for 1954, by H.M. Stationery Office. It forecasts that, should the recommendations of the Beaver Committee on Air Pollution relating to special processes be adopted, then there will be a substantial increase in the amount of work of the Alkali Inspectorate of the Ministry of Housing and Local Government. According to the report the number of works registered under the Alkali, &c., Works Regulation Act, 1906, was 927 and involved 1784 separate processes, while the total number of visits and inspections made during the year was 3961, including 531 visits to unregistered works and 107 visits to spoil banks. Full activity was maintained throughout the whole range of the chemical industry, especially with regard to sulphuric acid production, and the report notes the commissioning of new contact plants for the production of sulphuric acid from anhydrite and also the additional capacity for the production of chlorine. It is stated that the demand for cement continues and therefore all kilns have been operating at maximum throughput with shutdowns for repair only. Increased production of iron and steel has called for a corresponding increase in coke production, and the report records that this demand has been met by the commissioning of a new coke works and the completion of extensions to existing plant. The opening of a new terylene plant is mentioned, and also the increased demand for nylon. There has been an increase in the production of nitric acid, titanium dioxide, antimony, lead and benzene, while it has been necessary to keep old tinplate works in production. The part of the report concerned with Scotland states that there were eighty-two registered works representing 116 processes, and that 176 visits were made with an additional 149 visits to unregistered works. Both sections of the report give details of the investigations carried out at the various works and of the action taken to obviate troubles.

Advancement of Scientific Education

SEVENTEEN prominent British industrial organisations concerned in the chemical, electrical and mechanical engineering fields have decided to take steps to assist the teaching of pure and applied science and mathematics in secondary schools by establishing an industrial trust to be known as the Industrial Fund for the Advancement of Scientific Education in Schools. This fund has been set up as a result of the increasing anxiety which is being felt owing to the shortage of scientists, mathematicians and technologists. In announcing the fund, it is pointed out that public funds are available for capital works at maintained schools, but no such help exists for independent schools and direct grant schools. At many of these schools facilities are seriously inadequate through the lack of capital resources, and through the trust assistance will be given to them solely by the provision of capital grants towards the building, expansion, modernising and equipping of science buildings. For this purpose of assisting independent and direct grant schools the organisations concerned have guaranteed over £1,500,000, and it is believed other companies will also add their support to the fund, both in their own and the national interest. To administer the fund an executive committee has been formed, comprising, under the chairmanship of Sir Hugh Beaver, Sir Wilfrid Anson, Mr. R. A. Banks, Mr. E. H. O. Elkington, Dr. Willis Jackson, Mr. W. E. Jenkins, Professor G. F. Mucklow, Mr. J. A. Oriel, Dr. F. Roffey, Dr. C. P. Snow, Professor Sir Alexander Todd, Lieut-General Sir Ronald Weeks, and Mr. A. H. Wilson. This committee will adjudge and assess all applications and its decisions will take into account both the volume and quality of the existing science teaching in any school as well as the nature of the proposed extensions and improvements and the steps taken already by the school to help itself.

"Merchant Navy" Class Locomotives

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. I—PERFORMANCE AND EFFICIENCY TESTS

Among the various types of locomotives tested on the stationary plants of the British Transport Commission none embody greater departures from conventional practice than the Bulleid "Pacifics" of the former Southern Railway. The tests carried out at Rugby have proved of unusual interest, and in this article, and a succeeding one, the author comments upon the results now published, in the light of his own extensive footplate experience both on "Merchant Navy" locomotives and the smaller "West Country" class, which have similar design characteristics.

IN the history of the British steam locomotive, now drawing to its close, the Bulleid "Pacifics" will take their place as two of the most discussed and controversial classes ever to take the road in this country. Immediately upon taking over the post of Chief Mechanical Engineer of the Southern Railway from Mr. R. E. L. Maunsell, in 1937, Mr. Bulleid had under consideration the design of a locomotive larger and more powerful than anything hitherto running on that system, for the Continental and West of England traffic. At one time a 2–8–2 was contemplated, capable of mixed traffic service; for although the Southern is usually thought to be essentially a passenger line, there is a considerable volume of fast freight traffic between London and Southampton, and London and Exeter operated at night, and with larger and more powerful locomotives available some accelerations of these important services might be possible. The war supervened but, in view of the intention to use the new locomotives in freight as well as passenger traffic, work was pushed ahead and the first engine of the "Merchant Navy" class was completed early in 1941, at Eastleigh works. The designation "mixed traffic" still remains to-day, and is used in the bulletin describing the Rugby tests; but for some years now the "Merchant Navy" class engines have been used almost exclusively for express passenger service, and it is as such that they are now considered here.

Before coming to the tests themselves certain basic features of the design need particular mention. Although incorporating many interesting and novel points of detail, these locomotives appear to have been designed round two major points of principle: that the boiler should steam freely in the worst imaginable conditions of fuel; that the engine mechanism should run satisfactorily with a very minimum of shed maintenance. On both these points Mr. Bulleid clearly foresaw, in the early years of the war, something of the difficulties that beset locomotive operation to-day, and so far as the engine mechanism was concerned he designed a totally enclosed valve motion, running in an oil bath. The boiler included the multiple-jet blast-pipe, following the Lemaître principles so successfully used in France; Mr. Bulleid had already applied these principles with success in his modernisation of the "Lord Nelson" class 4–6–0s on the Southern. To promote more rapid circulation of water at the firebox end and to facilitate steam raising, two thermic siphons were fitted.

In service both "Merchant Navy" and "West Country" class engines have been criticised as erratic, and the full thermodynamic trials conducted at Rugby bring to light some facets of their performance that contribute to this characteristic. But at their best both are very fast and powerful types and in spite of failures on shed, and on the road, they are generally well liked by the enginemen. At various times the author has had occasion to ride on engines of both classes over practically all routes of the Southern Region where they are regularly run, and subject to certain failings which will be mentioned in connection with points raised by the Rugby report, they have shown themselves easily master of the heaviest tasks. Failures of the motion sometimes, however, lead to serious delay. Due to the total enclosure not only of the motion itself but of the centre big-end, it is difficult for a driver to detect when over-heating takes place, and instances have occurred of complete collapse, with puncture of the oil bath.

A Difficult Engine to Test

The bulletin now issued by the British Transport Commission has been prepared by the Rugby and Derby testing staffs, as a result of stationary plant tests, and of controlled road tests with the London Midland Region No. 1 dynamometer car between Skipton and Carlisle. The tests, which continued at intervals over nearly two years, concerned not only the locomotive as originally designed, but the effects of using a modified chimney and blast-pipe, and also the effect of a firebox without thermic siphons. One might interject here that it is fairly common knowledge that the locomotives in question are, in general, heavier on fuel and maintenance costs than locomotives of similar power operating elsewhere on British Railways, and advantage has been taken of the facilities available at Rugby to carry out certain pieces of research work.

The bulletin opens with a foreword that we may quote in full:

"This design of locomotive proved to be difficult to test owing to its inconsistent performance, especially with regard to power output. Not only was it often found impossible to obtain reasonable accuracy of repetition on different occasions but the performance would sometimes change appreciably over quite short periods of time. The changes were usually not of such magnitude as would have affected the locomotive's ability to carry out its normal duties quite effectively, but were such as to make accurate measurement exceptionally difficult, especially on the stationary test plant. These phenomena are of a kind known to be characteristic of this class of locomotive and are not peculiar to the one tested, though their occurrence may vary from one engine to another and from time to time. For this reason the test results cannot be regarded in all respects as being as soundly established as is normally the case, and must be taken as a general representation of the performance of the class rather than as exact results for any particular engine at any one time."

At the outset one would comment that such variations could be traced to behaviour of the valve gear, though apparently any research into the performance of this mechanism lay outside the brief of the testing staffs on this occasion. One is naturally curious to know more; in the bulletin the peculiar form of certain graphs may be studied, but without any suggestion or explanation of the factors giving rise to them.

"Merchant Navy" class locomotive handling the "Atlantic Coast Express"

The testing procedure, both on the stationary plant and on the road, has followed established practice, and at Rugby tests up to the high rate of 42,000 lb of feed water per hour were conducted. This latter figure is by some margin the highest yet published for a British locomotive; but the bulletin reports that in these conditions there was a tendency for mechanical failures to occur, such as heating of coupled axleboxes, inside big-ends, coupling-rod bushes, and so on. In these circumstances, it was evidently not deemed advisable to press the engine to such an extent in the road trials, and there the maximum steaming rate was limited to about 29,000 lb per hour. In contrast to previous bulletins prepared from tests carried out

with the Derby dynamometer car no graphic record of any one journey is included. The report states that the steam rate just quoted was sufficient to work a twenty-coach train of 594 tons tare over the heavily graded route between Skipton and Carlisle "at the scheduled speeds involved." What these are is not stated, but after commenting that the load was the greatest number of bogie coaches ever operated in one train over this route, this further point is added : that the load was over 40 per cent above the rostered tare load, on limited load schedules, for a class "7" 4–6–0—that is, a "Royal Scot," the most powerful locomotive normally permitted over the route. "The Thames–Clyde Express" running non-stop in each direction between Leeds and Carlisle is allowed 103 min northbound, and 105 min southbound, over the 86 miles between Skipton and Carlisle, including the crossing of Aisgill summit, 1161ft above Ordnance Datum. The maximum load for an unassisted "Scot" is 420 tons, but whether the "Merchant Navy" test runs were conducted on these same schedules is not made clear in the bulletin. In view of the difficulties in testing enumerated in the report, however, it would have been very interesting to see how near to a constant rate of steaming it was possible to hold the engine on a road trial of such severity.

Power Variations

Much of the difficulty in testing arose from the special nature of the valve gear, and again the preamble to the report contains some highly interesting passages that may be quoted :

"It was found that the actual cut-off bore no definite or consistent relationship to the setting of the reversing gear, not only for the locomotive as a whole, but especially for the individual cylinder ends. In the shorter cut-offs particularly, there was a general tendency for the actual mean cut-off to lengthen with increasing speed, but not in a smooth or regular manner. The power output in the short nominal cut-offs in the upper part of the speed range was found to be greater than that of other locomotives, size for size, and was in some cases more than would theoretically be possible at an actual cut-off equal to the nominal cut-off, even assuming that the cylinders were completely filled up to the point of cut-off with steam at full steam chest pressure and that no early release occurred. The true cut-off must have been longer than the nominal. At times quite random changes occurred that appeared to be caused by minute changes of speed or boiler pressure. Some of these random changes were relatively small, but others were of relatively large amount. Whilst changes that occurred over a period of weeks or months might be ascribed to wear of the motion, however small, this could hardly be the case with changes from one day to the next, or which occurred, sometimes more than once, in a single test period. As an example of the difficulties the following case may be quoted :—Some tests had been carried out in 10 per cent cut-off at speeds from 15 m.p.h. upwards, and then some in 15 per cent cut-off. It was noted that the recorded pulls in the longer nominal cut-off at 15 and 20 m.p.h. were less than those for the shorter cut-offs, but that a reasonable relationship existed between the two at higher speeds. On the following day check plates were made and the recorded pull at 15 m.p.h. was double that of the day before and that at 20 m.p.h. more than half as large again as on the previous day ; at 30 m.p.h. and above, however, fair agreement was established.

"A further difficulty was that the locomotive at certain speeds and cut-offs was unstable in conjunction with the control system of the test plant brakes, so that the speed varied uncontrollably over a wide range, for example, from 21 to 29 m.p.h., with consequent rapid fluctuation in power output and steam consumption. This phenomenon resulted from the abnormal way in which the pull of the locomotive in certain conditions increased with rising speed, thus almost matching the rising brake characteristics instead of cutting across them as do the falling characteristics of locomotives with other valve gears : the effect was heightened by the time required by the brakes system to adjust itself, which is appreciable." As a result of all this, and the irregularity of the curves produced, it was considered necessary to make a larger number of observations than usual, as it was clearly unwise to interpolate between normally spaced observations.

Steam Reversing Gear

The steam reversing gear fitted to these locomotives is not an easy one to set to any degree of precision, and during the many footplate observations made by the author on locomotives in service no attempt has been made by any driver to work "on the lever" to any appreciable extent. The reverser has been set in some "compromise" position, such as a nominal 25 or 30 per cent and all variations of power obtained by adjustment of the regulator. Under the more precise conditions of the stationary testing plant it was found that the gear could not, by ordinary adjustment, be prevented from creeping very slightly. The bulletin adds :

"The amount of creep would not have been perceptible in service, but it was enough to prevent testing in uniform conditions on the plant. To overcome this trouble a number of special distance pieces were made, against which the reversing gear could be held in a definitely fixed position. These distance pieces, however, could only be inserted whilst the locomotive was stationary, making it impossible to alter the gear to any other definite position once the locomotive was running. The reversing gear was modified for use during the tests on the line to make fine adjustments possible ; but, due to the need for continual alteration of the cut-off with changing speed, the small creep did not cause any difficulty." In this latter connection it would again have been very interesting to see just how fine the adjustments were, from a graphic record of one of the runs, since the method of handling was so diametrically opposed to that employed in normal heavy express service.

Slipping

One of the most unfortunate and pronounced characteristics of both classes of Bulleid "Pacific" is the liability to slipping, not only when starting, but while on the run. This, according to the bulletin, is ascribed to the fact that it cannot be run for an appreciable time without lubricating oil reaching the wheel treads and, on the test plant, the rollers. Thorough cleaning before every test and wiping of the test plant rollers at frequent intervals were necessary to enable any high-powered tests to be completed. Whereas usually a severe slip can be tolerated on the line, and on the plant results only in the need to repeat the test in progress, with this locomotive it was also liable to lead to buckling of coupling rods, which occurred on a number of occasions during the tests on the plant and on the line.

It was the possibility that such slipping might give rise to more serious damage to the locomotive and to the test plant that made it inexpedient to attempt to find the true "front end limit" with either South Kirkby or Bedwas coals, or to define it very precisely with Blidworth. As such rates of working, in any case, are beyond the ability of one fireman to maintain in service, no advantage was to be gained from attempts to obtain the utmost possible output from the boiler.

Again quoting from footplate experience with ordinary service trains, it would seem that, quite apart from oil reaching the wheel treads, the limits of adhesion must also be approached from other causes at times. The "Merchant Navy" class seem highly susceptible to wet rails. The author recalls particularly two runs on Continental boat expresses between Dover and Victoria on which serious slipping took place over certain lengths of the line. On the first, with the Night Ferry train, on leaving Dover in a light rain the engine seemed totally incapable of getting any grip on the rails until the train entered Shakespeare Cliff tunnel ; then recovery was immediate, and the performance thereafter was excellent. The second experience came in a journey on which a high power output was developed on certain sections. With a dry rail the start from Dover had been vigorous, and it was on the fast stretch westward from Ashford, while travelling at over 80 m.p.h., that a squall of rain occurred. Almost at once the engine slipped violently, and for the next fifteen minutes progress was a frequent succession of slips and closings of the regulator, all at speeds of between 70 and 80 m.p.h. It is in conditions such as this, one can well imagine, that buckling of the coupling rods takes place.

That it was probably due to the rail conditions, and not primarily to oil leakage within the locomotive is suggested by the performance on the heavy gradient from Tonbridge towards Sevenoaks tunnel. Here, on a gradient of 1 in 122, a speed of 53 m.p.h. was sustained until the train was checked by adverse signals. With a load of 406 tons tare behind the tender an equivalent drawbar horsepower of some 1900 was involved, and this big effort was developed without any tendency to slip. The experience at Rugby in conditions of high power output was in one respect repeated on this journey, in that on arrival at Victoria the right-hand driving axlebox was found to be overheated. On the road trials over the Settle and Carlisle line no mechanical troubles other than buckled coupling rods were experienced, although there the engine concerned, No. 35022, was not pressed beyond a steaming rate of 29,000 lb per hour. On the boat train journey just mentioned the indications were that for short periods the sister engine, No. 35028, was steaming at some 35,000 lb per hour.

Different Coals

One condition prominently in mind when the "Merchant Navy" class was originally designed was the need to ensure adequate performance with any grade of coal likely to be experienced in service, and the special features of the boiler, firebox and front end were included with that in view. In ordinary working, engines of this class are fired variously with hard coal, different grades of soft Welsh, and with soft Kentish, and with the Continental boat trains in particular it is normal practice to load the tenders with hard coal in London and take on further supplies

from Kentish pits at Folkestone or Dover. The firing technique is varied accordingly, and in general no difficulty seems to arise on this account. In the trials at Rugby engine No. 35022 was put through separate trials with three grades of coal, namely, South Kirkby, a grade 1A hard South Yorkshire ; Blidworth, a grade 2B hard East Midlands ; Bedwas, a grade 2A soft South Wales. The bulletin includes graphs of performance with the above coals, and also certain other graphs showing the effect of changes in draughting, using a single blast pipe, and in firebox design by removal of the thermic siphons and substitution of a conventional brick arch.

While it is unfortunate in a way that the mechanical troubles experienced on the test plant at high power output somewhat naturally deterred those responsible from attempting to establish the maximum steaming rates for the boiler when using the three specified grades of coal, in the more practical ranges of performance some interesting results were obtained. In the following table the values of steam to cylinders, per hour, are given for firing rates of 3000 lb and 4000 lb of coal per hour. The author has selected these rates in particular as representing the maximum one could expect to be maintained in service for any length of time by hand firing, and the maximum likely to be reached intermittently in heavy express service.

Evaporation, Pounds per Hour : Steam to Cylinders

Grade of coal	Firing rate, lb/hr		Calorific value of coal.* B.Th.U./lb
	3,000	4,000	
South Kirkby ..	24,000	29,500	13,994
Blidworth	20,800	26,000	12,887
Bedwas	23,000	29,000	14,229

* As received

With South Kirkby coal, tests were continued until the high rate of 42,000 lb of steam per hour was reached ; but to attain this the firing rate had to be pushed up to no less than 7000 lb of coal per hour, and even with two firemen this would mean very hard work.

(To be concluded)

Precise Measurement of the Diameter of Fine Wires*

By I. G. MORGAN, B.A. (Oxon)

The apparatus described in this article has been developed to provide a means of measuring fine wire up to about 0·01in (0·25mm) in diameter, to an accuracy of ±0·000 01in (0·25μ) or better. A pivoted beam carries an anvil which contacts the wire, whose diameter governs the tilt of the beam. The angle of tilt is measured by means of a mirror and autocollimator and the diameter of the wire may thus be determined. A feature of the design is the use of a light contact load at the anvil so that errors of measurement due to compression of the wire are minimised.

THE apparatus to be described has been developed in the Metrology Division of the National Physical Laboratory to provide a means of measuring fine wire up to about 0·01in (0·25mm) in diameter to an accuracy of ±0·000 01in (0·25μ) or better. A characteristic of the design is the use of a very light contact load at the measuring anvils so that when the wire is of very small diameter, or of soft material, errors of measurement due to compression of the wire are reduced to a minimum.

Fig. 1 illustrates diagrammatically the principle of operation used. The wire to be measured lies with its axis horizontal between two anvils, one fixed and the other movable. The fixed anvil is attached to the base plate of the apparatus and the movable anvil to a balanced beam which can tilt about a horizontal axis. Attached to the beam is a small plane mirror which may be viewed by an appropriately placed autocollimator. The angle of tilt of the beam and therefore of the mirror, varies with the diameter of the wire between the anvils. Variations in this angle are measured by means of the autocollimator and the distance from the centre of the movable anvil to the axis of tilt of the beam is such that a change in diameter of 0·000 005in (0·125μ) gives rise to a change in angle of 1 second of arc. The autocollimator readily detects a change of this magnitude.

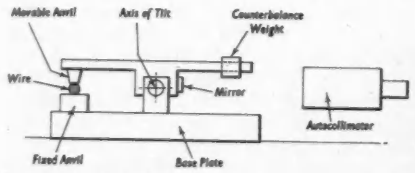


Fig. 1—Principle of measurement of diameter of fine wires

The construction of the apparatus is shown in Fig. 2. The upper surface of the hardened steel base plate is lapped so that slip gauges, which form the lower (fixed) anvil, may conveniently be wrung to it. Attached to the base is a steel U-piece in which are mounted the selected precision ball bearings which form the pivot for the tilting beam. The ball bearings are mounted in such a manner that they are slightly loaded axially so as to take up any play which may be present in the races. The tilting beam carries the movable anvil at one end, the actual contact face being a lapped flat of circular outline 0·05in (1·25mm) in diameter. The other end of the beam consists of two rods threaded over a portion of their lengths. On to each of these rods screws a cylindrical weight and by moving the weights along the rods the balance of the beam, and thus the contact load at the anvils, may be closely adjusted, the weights being then fixed in any desired position by means of locknuts. The mirror is fixed to the beam in a position between the threaded rods as shown. Mounted on the base is a bracket carrying a knurled screw which, when screwed inwards, bears down on one of the rods. The anvil may thus be raised or lowered by turning the screw in the appropriate direction. The ends of the spindle carrying the beam in the ball bearings pass completely through the inner races and protrude outside the U-piece. Rigidly attached to these ends are arms which hang downwards and carry " pendulum " weights. These weights may be moved up and down the arms so that the position of the centre of gravity of the tilting beam (of which the pendulums form an integral part) may be adjusted in the vertical plane. Such adjustment facilitates the setting of a very light contact load at the anvils.

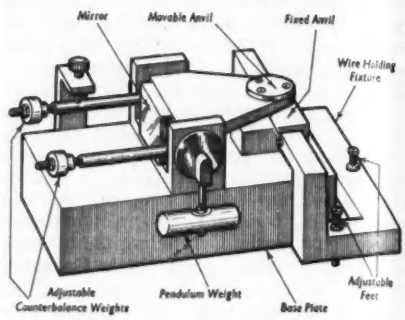


Fig. 2—Arrangement of apparatus for measuring diameter of fine wires

The manner in which the instrument is used depends on the kind of measurement required. Two applications will be described, first, the determination of the absolute diameter of a wire, and, secondly, the investigation of variation in diameter along the length of a wire.

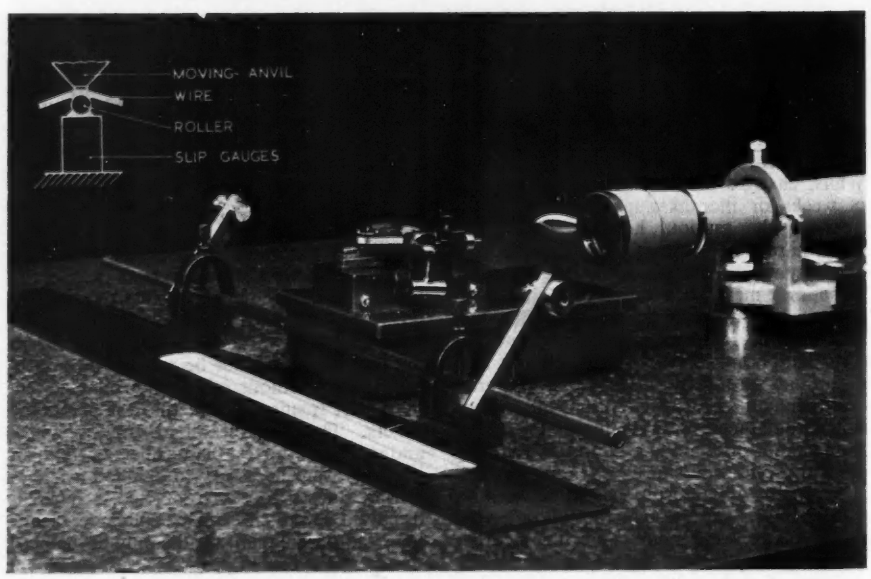


Fig. 3—Apparatus for measuring variation in diameter along the length of a wire

* Communication from the National Physical Laboratory.

For the determination of absolute size the lower anvil consists of a pile of slip gauges wrung to the base plate under the movable anvil. The reading of the autocollimator is first taken when the movable anvil rests directly on the upper surface of a slip gauge pile of height, say, $h_1$in. This slip gauge pile is then replaced by another of height $h_2$in with the wire, of nominal diameter, say, $d$in, resting on it. The height $h_2$in of the second slip gauge pile is chosen so that $h_1=h_2+d$. With the movable anvil now resting on the wire a second reading of the autocollimator is taken so that the difference between the two readings enables the actual diameter of the wire to be calculated. Clearly, if an accurate result is to be obtained it must be ensured that when the moving anvil is in the measuring position on the first slip gauge pile the surfaces of anvil and slip gauge pile are accurately parallel. This is done by lapping the contact face of the anvil *in situ* using a parallel faced lap located off the base plate. The height $h_1$in of the slip gauge pile is then made equal to the thickness of the lap, which is nominally 0·5in (12·5mm). It must also be ensured that the wire to be measured is in proper contact with both anvils. For this purpose the wire is mounted in a suitable fixture, an example of which is seen in Fig. 2. The position of the fixture is set by means of three adjustable feet so that the wire, lightly tensioned, lies flat across the surface of the fixed anvil and just in contact with it. This setting must be carried out with care, particularly when a very light contact load is being used. It is not, in general, necessary that the wire should lie precisely under the centre of the moving anvil, so that positioning may conveniently be done by eye, but if this is desired it may readily be arranged by locating the fixture holding the wire against appropriately placed stops. A displacement of the wire from the central position does, of course, give rise to a slight change in sensitivity, but since h_2 is always adjusted so that the measured quantity (given by the difference between the two readings of the autocollimator) is small any error so introduced is negligible.

Fig. 3 illustrates an arrangement whereby a specimen of wire may be examined for variation in diameter along its length. The instrument is set up on a surface plate with the wire mounted in a fixture which may be traversed along a straight edge. A pointer attached to the fixture registers against a scale on the straight edge and a series of readings at known positions along the wire may thus be obtained. For this purpose, since variation in diameter only is being measured, a fixed anvil of the form shown in the inset in Fig. 3 can be used with advantage. The wire is lightly tensioned in the fixture and its position in relation to the fixed anvil is adjusted so that it is always in contact with this anvil as it is traversed. In the particular mounting fixture shown in Fig. 3 the clamps holding the ends of the wire may be rotated about an axis coincident with that of the wire, so that variation in diameter in a diametral section may also be investigated if so desired. (It should be noted that in actual use the instrument and straight edge as shown in Fig. 3 should be firmly clamped to the surface plate. The necessary clamps have been omitted from the illustration in the interest of greater clarity.) The use of the instrument at the National Physical Laboratory has so far been largely restricted to the measurement of diameter in the range 0·002in (0·05mm) to 0·006in (0·15mm), but absolute determinations of diameter have also been made successfully on wires of nominal diameter 0·000 15in (4μ), using a contact load of about 1 gramme weight. A further application envisaged is the measurement of the diameters of small precision balls.

The author wishes to acknowledge the assistance given by Mr. J. Wilson, who constructed the instrument. The work described above has been carried out as part of the research programme of the National Physical Laboratory and this article is published by permission of the Director of the Laboratory.

On the Construction of the Britannia Bridge

By WILLIAM KELLY WALLACE, C.B.E.

The Institution of Civil Engineers' new president, for the session 1955–56, Mr. W. K. Wallace, delivered his presidential address on Tuesday last. Mr. Wallace was for many years chief civil engineer of the London Midland and Scottish Railway. He recalled that two railway engineers had recently been presidents of the Institution, and remarked that "the railway field, though fertile, has been under rather intense cultivation." His address, therefore, described the construction of the London to Birmingham trunk railway, under the direction of Robert Stephenson, in the eighteen-thirties, and went on to give an account of the building of the Britannia bridge. This latter section of the address is reproduced here.

WHILST the London and Birmingham Railway is an adequate memorial to Robert Stephenson's ability, it did not provide an opportunity to demonstrate his skill in the design of large bridges. This chance came later when he was appointed engineer of the Chester and Holyhead Railway, which necessitated the construction of two bridges of large span, that at Conway of 400ft, the other over the Menai Straits with two spans of 450ft. Both bridges are over tidal waters, and the sites precluded erection on falsework owing to navigation and rapid tidal currents.

The first application for Parliamentary powers was made in the session of 1843–44. The chief engineering work then involved was the bridge over the Conway, close to Telford's existing suspension bridge. The crossing of the Menai Straits was intended to be achieved by taking over one of the roadways of the suspension bridge for railway purposes. As this bridge was considered inadequate to carry trains with locomotives, it was intended to convey the trains across in a divided state if necessary, by horse traction, another locomotive being in readiness to be attached on the other side. Thus the passage of engines was entirely obviated. The Commissioners of Woods and Forests assented to the proposal, but with the condition that the use of the south roadway for railway purposes should only be temporary. The company, therefore, had to abandon this part of its plan and to propose an independent bridge for the railway. The Bill was permitted to pass, and the company instructed its engineer to deviate the line and select the best site for crossing the straits by an independent bridge.

Stephenson selected the site known by the name of the Britannia Rock, about 1 mile south of Telford's suspension bridge. He proposed to construct a bridge with two cast iron arches, each of 350ft span, the roadway being 105ft above high water ordinary spring tides.

At Britannia Rock, instead of two arches being erected on two abutments and one pier, the scheme was to erect three balanced cantilevers on three piers. The arches were to be built by placing equal and corresponding voussoirs on opposite sides of the pier at the same time, tying them together by horizontal tie-bolts. In November, 1844, the company deposited new plans preparatory to asking for powers to carry out the deviation.

The proposed bridge was opposed by the shipping interests, as rendering navigation more dangerous by restricting vessels to a narrower channel; it was also held that the massive piers and spandrels would shelter vessels from the wind in situations when it was of the utmost importance to them. These objections seemed likely to endanger the passage of the Bill, so Stephenson reconsidered the possibility of stiffening the deck of a suspension bridge so as to make it suitable for railway traffic at high speeds. This led to the idea of a huge wrought-iron rectangular tube, so large that trains could pass through it, with suspension chains on each side, and this, in turn, to the tube as a beam with the chains as auxiliaries.

Parliamentary opposition led to the Admiralty being asked for a report on the proposed bridge over the Straits. The report confirmed the site as the most suitable one available, but stated the proposed arch design would be detrimental to the interests of navigation. It said that the pier on the Britannia Rock should not be more than 50ft square, and be built on the highest part of the rock. Further, no pier or abutment should be erected on either side of the Straits projecting beyond the line of ordinary high water mark, and there should be a clear headway of 105ft above high water ordinary spring tides at every part under the proposed bridge where vessels passed.

Stephenson decided that a tubular bridge was the only structure which combined the necessary strength and stability for a railway. He informed the directors of the Chester and Holyhead Railway Company he was prepared to carry out a bridge of this description, and gave evidence to this effect before a committee of the House of Commons on May 5, 1845. He states: "the evidence which I gave before the committee . . . was received with much evident incredulity so much so that . . . the committee stated that they would require evidence, and especially that of the Inspector General of Railways before they could pass the bill authorising the erection of such a bridge."

The preamble of the Bill was passed, but a resolution come to, which left the question of the bridge entirely open for further consideration. The Bill passed the parliamentary committee and received the Royal Assent on June 30, 1845.

An important series of tests on the strength of various tubular constructions was now entered upon. The performance of the experiments was left to Mr. Fairbairn, and the beams were fabricated and tested in his

shipyard at Millwall. Mr. Hodgkinson, the eminent scientist and mathematician, also collaborated on the tests.

Twelve experiments were made on cylindrical tubes, seven on elliptical, followed by fourteen on rectangular tubes. These tests were spread over the period from July 6 to October 14, 1845. The tubes were of different lateral dimensions and spans, and were constructed of plates of different thicknesses. All were tested to failure by a concentrated load at mid-span.

Stephenson reported to the directors on the tests on February 9, 1846, " the object of this investigation . . . was to test the truth of the views I entertained respecting the employment of a large wrought iron tube instead of cast iron arches as was originally proposed, but which we were compelled to abandon in consequence of the Admiralty refusing to allow the erection of such a structure from the belief that it would injuriously interfere with the navigation of the Straits.

" In the course of the experiments, it is true some unexpected and anomalous results presented themselves, but none of them tended in my mind to show that the tubular form was not the very best for obtaining a rigid roadway for a railroad of a span of over 450ft, which is the absolute requirement for a bridge over the Menai Straits.

" Another instructive lesson which the experiments disclose is that the rectangular tube is by far the strongest and that the circular and elliptical should be discarded altogether."

Stephenson considered some further experiments were required, but " in the meantime, however, as I consider the main question settled, I am proceeding with the designs and working plans for the whole of the masonry, which I expect to have the pleasure of submitting to you in a fortnight from this time."

Accompanying this report were separate reports from Messrs. Fairbairn and Hodgkinson giving details of the tests.

The last series of experiments, from July, 1846, to April, 1847, were made on a large model, one-sixth full size. Six tests were made, and after each one weak points in the model were made good. At the finish, Mr. Edwin Clark, the resident engineer, wrote : " the magnificent model . . . failed at length from the crushing of the top, after carrying a greater weight than even a double line of locomotives throughout the whole length. Nothing could be more satisfactory than this result ; an addition of material of only 1 ton to a beam weighing originally only 5¼ tons, having increased the breaking weight from 35½ tons to upwards of 86 tons."

The final design consisted of two wrought-iron tubes each carrying one track. There are two land spans of 230ft and two over water of 459ft each, the overall length of each tube being 1511ft. The depth of the tubes increases from 22ft 9in at the ends to 30ft at the central Britannia tower, and each has a width of 14ft 9in.

Both upper and lower chords are of cellular construction. The upper is of eight cells, 21in by 21in, and the lower of six cells, 2ft 4in by 21in. This form of construction was adopted for the top member to obviate any risk of buckling, particularly when the tube was being jacked up into position as a simple span. The bottom member is in compression at the three towers, as the tubes are continuous over the four spans, and a cellular form is also desired to reduce the length of the rivet grip.

The tubes are supported on two abutments and three towers of masonry, and are carried through the towers partly on roller bearings and partly suspended from spade bolts hung from movable cast iron beams, with the exception of the Britannia tower, which has fixed bearings. The towers are carried above the tubes so as to carry suspension chains originally intended for support during erection or possibly permanently. As the estimated weight of each water span of the tubes was 1285 tons and its length 472ft, the method of erection had to be decided upon before the site for its assembly could be selected.

The scheme originally favoured by Stephenson was to construct a suspension bridge of sufficient strength to carry the tube, the roadway of this bridge being at the intended level of the tubes, and to construct platforms at the same level at each approach to the suspension bridge, and on these platforms and on the bridge to lay a railway. Then to construct the tube on the railway on a line of trucks, load the suspension bridge with a train about equal in weight to that of the tube and draw the tube on to the bridge at one end simultaneously with the withdrawal of the line of loaded trucks at the other so as to prevent any great undulation in the suspension bridge. The chains of the temporary bridge would be available as additional support for the tubes if desired.

Plans for the masonry were ready on March 17, 1846, and the first stone in the foundations was laid on April 10th by the resident engineer for the masonry, Frank Forster. Work went on steadily ; the side towers were completed on February 22, 1849, and Stephenson laid the last stone on top of the Britannia tower on June 22nd, 1849.

A quotation for the supply of the suspension bridge was received, the figure being much higher than expected, and as it was intended to build the tubes to be self-supporting in any case, discussion of schemes for erection was resumed in the hope of dispensing with the suspension bridge.

Mr. E. Clark, the resident engineer, noticed contractors raising a small water tank at Crewe by jacking, and thought the same method might be used for raising the bridge tubes. Stephenson finally agreed to using this method, and the towers were built with vertical recesses to receive the ends of the tubes when floated into position.

The tubes for the 230ft land spans were built *in situ* on temporary timber staging. The staging on which the four water-span tubes were built was constructed on the Caernarvon shore. When assembled, these tubes were floated on eight pontoons and warped into position, being landed in the recesses in the towers at or about high water.

The control of operations when the tubes were afloat was given by Stephenson to Captain Claxton, R.N. The scheme was to warp the pontoons bearing the tube out from the shore, swing the tube by the tide, and let it drift towards the towers, getting it into proper position by lines controlled by capstans mounted on the shore, and depositing it on the masonry by the falling tide. The rapid currents in the Straits made this a hazardous operation, but all the tubes were successfully landed.

They were raised to their correct level by hydraulic rams fixed near the top of the towers, the tube being suspended on a multiple link chain at each end. The rising tube was followed by timber packing in the centre and by brickwork in Roman cement at each side. The ram stroke was 6ft, and lifted the tube approximately 2in per minute.

The importance of following the rising tube with packing was demonstrated on August 17, 1849, when the press at the Anglesey end of the first tube to be launched failed by the bottom of the cylinder breaking away from the body, the tube dropped on the timber packing which was severely crushed, and the special lifting frames and beams at the tube end were severely damaged. The bottom plates of the tube were bulged inwards 3in to 4in, and the curvature extended for 40ft along the tube. All was made good, and lifting was resumed on October 1st, and the final elevation was reached on the 13th. The junction piece carrying the tube across the tower was riveted to it and the tube lowered on its permanent bed on November 9th.

The second tube between the Caernarvon and Britannia towers was floated on December 4th and set on its permanent bed on February 7, 1850. The two tubes above mentioned now form part of the up line.

To develop the support moments so that the bridge would act as a continuous girder, the tubes were tilted before riveting to the junction pieces and afterwards lowered on their permanent bearings, thus causing a negative moment at the towers. It seems, however, that Stephenson did not fully attain his object, as the moments at mid-span are greater than those over the support.

This operation was completed on March 4, 1850, and on the following day three locomotives passed through. Stephenson and the contractor drove the last rivet and a train of three engines, forty-five loaded wagons, and carriages containing 700 persons, weighing in all 503 tons, passed through the tubes to Holyhead. The Government inspection took place on March 15th, and the line opened for public traffic on the 18th. The superstructure for the down line was then proceeded with, and opened in October, 1850.

The abutments were similar in plan, but owing to the configuration of the ground the Caernarvon one is 88ft high, whilst the Anglesey one is 143ft. The lintels over the entrances to the tubes are single stones 20ft long, both on abutments and towers. At the ends of the abutment wing walls are colossal lions couchant on pedestals. Their length is 25ft and each weighs 30 tons. They were designed and executed by Mr. Thomas, who was engaged on sculpture for the Houses of Parliament. He also designed a colossal figure of Britannia for the centre tower, but its great cost prevented its construction.

The total masonry in the bridge is 55,265 cubic yards, weighing 104,875 tons. Almost half of this mass of material was brought from quarries in Anglesey, opened and worked by the contractors for the masonry. The average height to which it has been raised is 80ft, and two and three-quarter years were occupied in its erection. Throughout that time it was set at the rate of 3 cubic feet per minute ; from 500 to 600 men were continuously employed on the erection, and a further 300 to 400 in the quarries and in bringing the stone to the Straits. The weight of wrought ironwork in the bridge is 9360 tons and that of cast iron 1987 tons. The cost of the bridge was : masonry, £158,704 ; ironwork and erection, £443,161—a total of £601,865.

The bridge has given continuous service without alteration to the present date. Careful maintenance has been continuous, and apart from the renewal of a few of the spade bolts, repairs have been negligible.

Another tubular bridge was designed and constructed by Stephenson for the Grand Trunk Railway over the St. Lawrence River at Montreal in 1859. The type is now obsolete, due largely to advances in the iron and steel industry, both in the metallurgical and manufacturing fields. I hope the foregoing shows how fortunate this country was in possessing an engineer such as Stephenson at the beginning of the railway era.

Opening of the Neath By-pass Bridge and Viaduct

THE bridge and viaduct forming the new Neath by-pass in South Wales were opened to traffic last Monday by the Minister of Transport and Civil Aviation, Mr. J. Boyd-Carpenter. The cost of the new works is about £2,000,000 and no other bridge construction of comparable size has been carried out in this country since the war. Work was started on the Neath scheme early in 1949. Since that time, we have recorded its progress in these columns on several occasions.

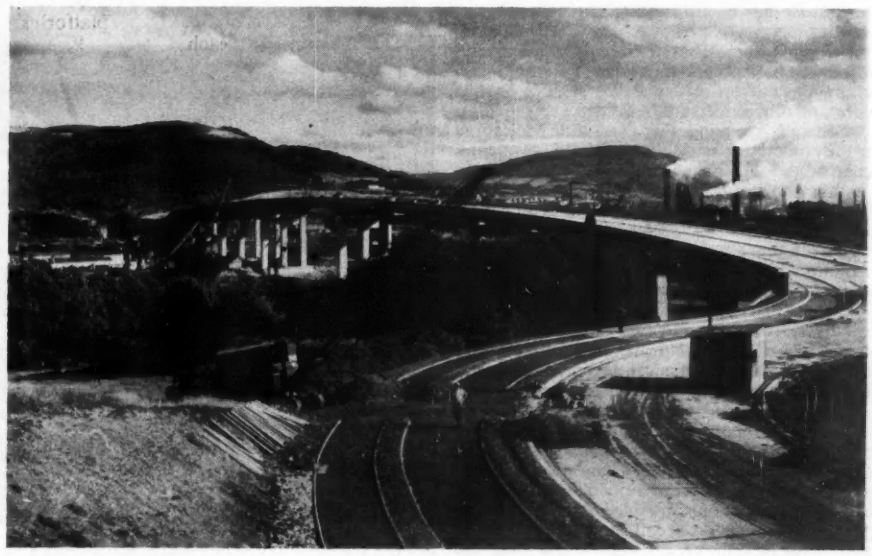
The accompanying illustration gives a good idea of the completed scheme, but only one of the two viaducts is shown. The high-level road which they both form is about three-quarters of a mile in length, with a width between parapets of 90ft, comprising two 22ft carriageways separated by a 6ft central reservation, and flanked on each side by a verge, cycle track and footway with widths of 5ft, 9ft and 6ft respectively.

Starting at the eastern end with the large Briton Ferry roundabout forming a junction with the A.48, the new road rises gently on a viaduct 972ft long with eleven steel spans which crosses over the main London and Fishguard railway line, the Briton Ferry dock and the industrial sidings alongside. It then enters a short cutting in Warren Hill, which stands on the eastern bank of Neath River. To the west of this hill the road is carried on a steel viaduct structure, 1610ft long, with seventeen spans, over more railway sidings, the Jersey canal, the Neath River and the saltings on its western bank. Steel construction is employed throughout for the seventeen spans. The River Neath crossing in the centre of this viaduct comprises a three-span bridge which gives a clearance of 90ft above the high-water level in the river. The central span is 300ft in length, and the eight side spans are each 140ft. The central span consists of two 88ft cantilevers, each balanced by the 140ft anchor arms at the sides, and a central suspended span of 124ft.

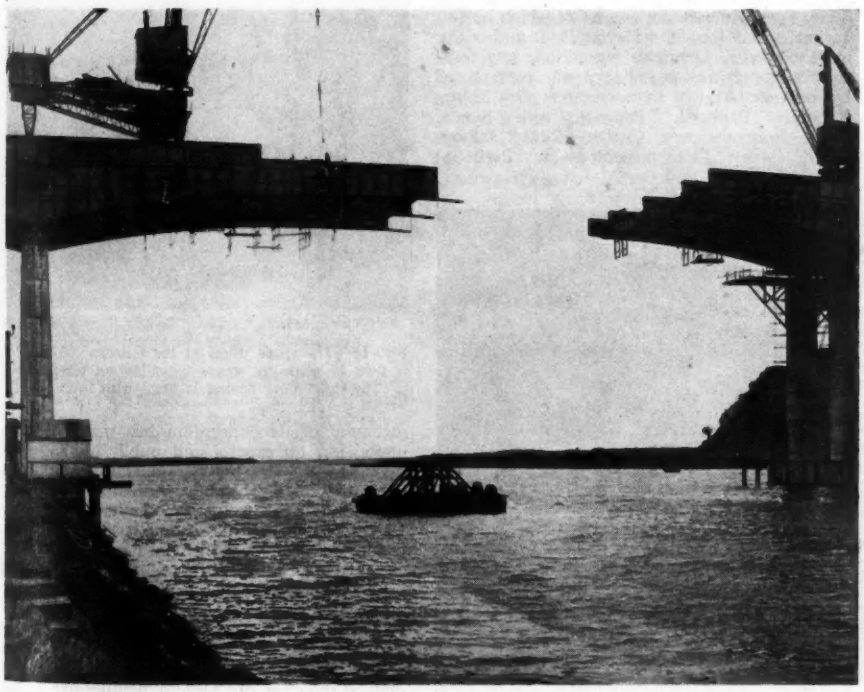
The steel members of the superstructures of the two viaducts are riveted. The approach spans are of mild steel plate girders. The main bridge over the river is also of plate girder construction and incorporates triple longitudinal members of high-tensile steel. Between the cantilevers resting on the two river piers and the suspended span in the centre, there is a pin joint on one side and a link joint on the other. Travelling and fixed derricks were used extensively in erecting the steel members. The reinforced concrete deck slabs are finished with asphaltic base courses and wearing surfaces. Removable concrete slabs cover the ducts for public services. Our second illustration shows the 300ft span under construction.

Cross-sectional details of the bridge steelwork were published with our description of the scheme in THE ENGINEER of March 2, 1951. But the principal description we gave on that occasion was concerned with the foundations. Varying methods of foundation construction had to be adopted throughout the length of the two viaducts, due to somewhat unfavourable subsoil conditions. The two main river piers are founded on compressed-air caissons, 9ft diameter cylinders having been sunk, and then connected together in pairs with reinforced concrete caps.

For much of the work on the Warren Hill/Earlswood section, however, reinforced concrete monoliths have been sunk by hand excavation and grabbing. Generally, three monoliths were sunk at each pier; each one consisted of a "box" of heavily reinforced concrete, 23ft 6in square, with cross walls. As excavation proceeded, Kentledge was added to the monolith, and its walls were built up as it was sunk, until the required depth was reached. In one case, a monolith was sunk to a depth of 50ft. On completion of sinking, the base of the monolith was concreted, and its top was trimmed to level; it was then filled with water and a reinforced concrete cap built over it, to form the base of the reinforced concrete column carrying the steelwork above.



The River Neath crossing with a central span of 300ft is shown here, from the roundabout or Earlswood end of the viaduct



Construction of the 300ft span of the River Neath crossing is here shown in progress. The main girders of the two cantilevers are in position, and work on the suspended span is in progress

The new route will shorten the journey of traffic to Swansea by about 6 miles. It links with a new dual carriageway road from Earlswood which will eventually continue to Swansea. Other associated road improvements are envisaged.

The Neath by-pass was authorised by the Minister of Transport in 1948. Messrs. Rendel, Palmer and Tritton were the consulting engineers, with Sir Percy Thomas as architect. The work was carried out by the Cleveland Bridge and Engineering Company, Ltd.

ECONOMY IN THE USE OF CEMENT.—We are informed that a total of 3630 tons of cement was saved on Ministry of Works sites in the placing of 124,482 cubic yards of concrete on seventy sites during the year ended April 30th last. This economy was achieved by having concrete placed according to guaranteed strength specifications and mix design methods used by the Ministry instead of in the manner that earlier standard specifications would have required (see THE ENGINEER, December 10, 1954). Altogether 117 different concrete mixes were required and on all but six sites these were designed at the contractors' request by the Ministry's engineers. The Ministry would like to see more contractors designing these mixes themselves to suit materials locally available. The new guaranteed strength standards call for compaction by high frequency vibration for all quality-controlled concrete. It has been noted with satisfaction that contractors are tending to use vibration even when it is not specified. For compacting thin slabs in contact with the ground the most suitable process seems to be the vibrating roller, and the Ministry hopes to extend the use of its specification for consolidation of this kind.

The 1955 Motor Show

No. II—(*Continued from page 601, October 28th*)

IN our report last week we dealt with the British cars first exhibited at this year's Show. Turning now to foreign exhibits, we note that the American manufacturers were again represented in full strength. No less than seventeen firms were displaying an impressive collection of mainly new models, intended not for sale here, but in such overseas countries as have no import and currency restrictions. One of their characteristics is an almost uniform appearance which sometimes makes it difficult to distinguish between the various makes. All of them seem to be alike in their ample dimensions, their lavish equipment, low swept bonnets and low-placed louvres for the air intake on top of a massive bumper having substantial overriders.

Generally speaking, there was little indication of any notable change in the well-known concept of the American car (Fig. 9), apart from modifications in body styles and ornamentation. The hard-top coupé is very much in favour with the American public, and servo braking is almost universal for all the faster and heavier cars. Additional equipment, obtainable at an extra cost, includes such items as air conditioning, power-assisted steering, electric operation of windows, front seats and even of the antenna for the car wireless set. No major alterations were apparent in the mechanical layout, which as a rule is characterised by high-powered engines of ample cylinder capacity, automatic transmissions, wishbone-cum-coil spring front suspension and rigid live rear axles in conjunction with orthodox leaf springs. There were only two exceptions from the conventional layout of the rear suspension, one provided by the 5·2-litre Buick, which employs coil springs at the rear with a torque tube to carry the thrust, and the other by Packard, which uses torsion bars. The interesting feature of the Packard suspension is the adoption of a single torsion bar on each side which links the front and rear wheels, the former being mounted on conventional wishbones, the latter on trailing torque arms. Stabiliser torsion bars are fitted front and rear. The rear halves of the longitudinal torsion bars are reinforced by two supplementary torsion bars, which are mounted parallel to the main bars and are automatically wound up by an electric motor when the load on the rear axle is increased.

Engines of less than 3 litres cylinder capacity are rare, side valve engines practically dying out. Eight-cylinder vee engines, always push-rod operated, are the most popular power units of more than 4-litre capacity, as their compact layout permits low and short bonnets in spite of the engine size. The compression ratio has generally gone up to more than 8 : 1 and some of the latest cars, like the new Lincoln, the Ford "Mercury" and the Ford "Continental," are using compression ratios up to 9 : 1. These high compression ratios are, of course, only suitable for the large American engines, which rarely run at full load; further, high octane petrol is taken for granted in America and the almost invariable automatic transmission effectively limits excessive full-torque operation of the engine.

No major modifications have been announced in the design of transmission units, apart from the use of a push-button gear selector by Chrysler. Instead of the usual selector quadrant, the "Powerflite" transmission is now controlled by four buttons on the driver's side of the instrument board. A hydraulic interlock prevents a transmission shift to reverse whilst the car is moving forward at more than 10 m.p.h. Another safety device prevents the engine from being started in any gear other than neutral. Mention should be made of the Lincoln, the 6-litre vee eight-cylinder engine of which has an output of 285 h.p. (S.A.E. standard) and is the most powerful American automobile engine.

The French motor industry was represented by such well-known manufacturers as Citröen, Renault, Panhard, Peugeot, and Simca. Apart from the new Citröen 2-litre saloon, which, when first presented in Paris at this year's Salon de l'Automobile, received a great deal of well-deserved publicity and was also one of the focal points at the London show, all the other French cars differ in minor details only from last year's models.

As the new Citröen "D.S.19" has already been described in detail in THE ENGINEER of October 21st, it may suffice to add that the British version, which is to be assembled at the Slough factory of Citröen Cars, Ltd., varies from the original construction only by having right-hand steering, a 12V electrical equipment, and a front bench seat with folding arm rest. It is seen in Figs. 10 and 11.

The Citröen "D.S.19" has been acclaimed as the most revolutionary car built in the last twenty years, and there is no doubt that the sheer ingenuity of its conception has made a great impression on experts and public alike. It is bristling with technical innovations and is likely to remain ahead of contemporary design for a long time to come, even as its predecessor, which, produced without any basic change for twenty-one years, is still considered one of the most advanced modern cars. There has been some scepticism, however, as to whether the admittedly complex hydraulic system with its belt-driven master pump, its maze of pipelines and the numerous sensitive valves, might not present major problems in maintenance. This may be the case, but these difficulties are by no means insuperable and will be overcome if the complexity of the design constitutes—and we

Fig. 10—The 2-litre Citroen has quickly-removable rear quarter panels for easy access to the wheels

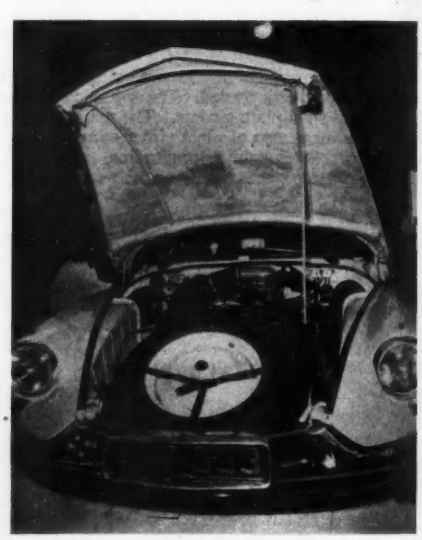


Fig. 11—The spare wheel of the Citroen "D.S.19" is held in place by straps including an elastic link. The light alloy bonnet is lined with insulation

Fig. 9—The Plymouth "Belvedere" typifies modern United States automobile styling

believe it does—a major contribution to the safety and the riding comfort of the modern motor-car. The replacement of the orthodox spring rear suspension by pneumatic means alone, in our opinion, would justify a considerable amount of technical effort and complexity. Further, the introduction of a central hydraulic system for the actuation of all mechanism involving a linear displacement, power steering and power braking, clutch and gear shift operation, &c., must be considered an important step in the right direction. Operations of this kind are difficult to effect by means of electric motors, and it seems only logical to add the hydraulic power system to the electrical power supply, delegating to each system the functions it can fulfil best. It is up to the engineer to provide the means of further technical progress, but to the buying public to accept or reject them according to the value received at the expense of higher initial outlay. Should the new Citröen indeed provide the amenities claimed by its designers, then it can be expected that many of its constructional details will be incorporated in future car design.

In view of the great public interest aroused by the 2-litre Citröen "D.S.19," it is only natural that the smaller type, the "2 C.V.," attracts mainly ardent students of automobile engineering. Modified in minor details only, it now has a 400 c.c. engine and is obtainable with a centrifugal clutch which allows gear changes between third and top gear without declutching.

A new gear-change aid has also been adopted for the rear-engined 750 c.c. Renault. This device, the "Ferlec" electromagnetic automatic clutch, gives two-pedal control with a fully synchronised gearbox, providing easy and silent gear changes. A magnetic flywheel is used with a circular coil embedded in it; current fed into this coil from the dynamo attracts an armature, the movement of which brings a pressure plate in contact with a Ferodo-lined friction plate, thus transmitting the drive. With the engine throttled down, the amount of current supplied by the dynamo is insufficient to take up the drive, but contact is made gradually as engine speed is increased. When the engine speed drops, the armature ceases to be attracted and declutching takes place automatically. The gear change lever contains an internal contact by means of which the current is momentarily cut and, through a relay, the throttle is closed at the moment of making a change.

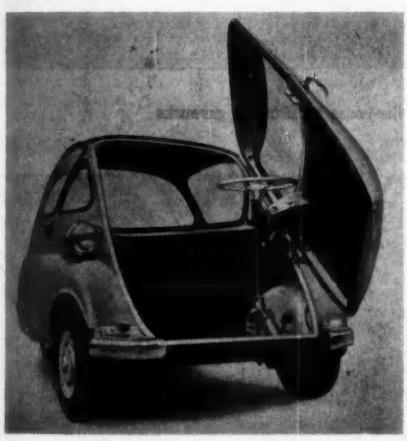


Fig. 11—The B.M.W. "Isetta" has a single door that carries the steering wheel.

The Simca "Aronde," one of France's most popular cars, now has an enlarged engine of 1·3 litres capacity, developing 48 h.p. at 4500 r.p.m. The "Aronde" also can be fitted with an electromagnetic clutch, basically similar to that of the small Renault, but independently developed by Simca.

The "Ferlec" automatic clutch is also obtainable for use in the new 850 c.c. Panhard front-wheel drive car. The main specification of this interesting car, which incorporates such features as a two-cylinder opposed, air-cooled engine with torsion-bar valve springs, remains basically unchanged apart from a clever system of adjusting the clearance between valves and rockers by oil-pressure-loaded pistons.

The German motor industry, represented by six firms, was showing the same models as were exhibited at the recent Frankfurt Motor Show, and described in our Show report. The only newcomer, not previously seen at Frankfurt, was the small "Isetta" motor-coupe of Bayerische Motoren Werke (B.M.W.), a car which attracted a good deal of attention because of its unusual egg-shaped bodywork (Fig. 11). The light runabout has a tubular chassis and a steel body which offers adequate accommodation in side-by-side seating for two adults and a child. The forward facing counterbalanced door permits easy entrance from the front as the universally jointed steering column moves together with the door. The torque is transmitted from the fan-cooled, single-cylinder, 12 h.p. o.h.v. engine of 245 c.c. capacity via a four-speed gearbox and an adjustable fully enclosed chain drive to the rear axle, which is suspended by two cantilever leaf springs. The rear track is only 20½in so that the rear axle needs no differential. The front track is 46½in and the independently sprung front wheels are suspended by bell-crank radius arms which bear on coil springs, enclosed in casings together with the telescopic dampers. The car, which is fitted with heater, hydraulic brakes and 4·80 (10in) tyres, has a wheelbase of 5ft 10in and a dry weight of 7 cwt. A maximum speed of about 50 m.p.h. and a fuel consumption of more than 80 m.p.g. is claimed.

The Italian contingent at this year's show again consisted of the three firms Alfa-Romeo, Lancia and Fiat. As expected, the design and the workmanship of the Italian cars was of the highest order, not only in regard to the body styling, but also in the mechanical layout and in detail design. A car which was particularly pleasing to the eye because of its clean, flowing lines, was the 1·3-litre Alfa-Romeo "Giulietta" open two-seater with a body designed by the well-known Italian stylist Pinin Farina.

From a technical point of view the most interesting Italian car was the Fiat "600," which replaces the well-known 500 c.c. "Topolino." Having the same 6ft 7in wheel base as its predecessor, the new four-seater has a shorter overall length than the 500 c.c. two-seater, but is 3½in wider, resulting in added seating comfort. Its dry weight of 11½ cwt is practically the same as that of the "Topolino." The remarkable achievement of accommodating four passengers wholly within the above-mentioned wheel base and in a car the total plan area of which amounts to no more than 47 square feet, has been effected by mounting the power unit at the rear.

The two-door saloon is built in integral construction and has independent all-wheel suspension. Rather stubby and somewhat utilitarian looking, it has not the handsome styling of other Italian types, but, like the 2 c.v. Citröen, it has the appearance of an entirely functional means of transportation. The front wheel suspension employs upper wishbones in conjunction with a transverse leaf spring, which is located on the body structure in two rubberbonded housings 22in apart. This system of flexible attachment points allows the spring to deflect under road conditions so that the upward movement of one wheel is followed by the opposite wheel, the whole system acting in the same way as a torsion bar stabiliser.

The general layout of the power unit resembles that of the 750 c.c. Renault. The engine is mounted at the rear, the torque being transmitted to the synchro-mesh gearbox, which is located ahead of the rear axle centres, and from there back to the bevel axle drive. The four gear ratios are all indirect, the overdrive having a reduction ratio of 0·9 : 10. In accordance with current Fiat practice, the second gear is housed in an extension casing ahead of the main box, and a transmission brake is mounted on the extension of the second motion shaft. Universally jointed swinging half-shafts lead from the differential gear to the 12in rear wheels. The swinging arm rear suspension consists of two triangular structures, each of which carries one wheel. The forward facing arm of each structure is attached to the gearbox bracket, the rear arm to a body cross member. The rubber-bushed pivot points are mounted some distance apart and define an axis inclined relative to the centre line of the car. The geometry of this suspension layout effectively reduces the tendency to oversteer which is characteristic for rear-engined vehicles.

The 633 c.c. o.h.v., four-cylinder engine of 60mm bore and 56mm stroke has a compression ratio of 7 : 1 and develops 21·5 h.p. at 4600 r.p.m. It is fitted with an aluminium cylinder head and the inlet manifold has been eliminated by incorporating the intake tract in the cylinder head; the air filter is mounted on the rocker gear cover and there is an optional warm air intake. A saving in length has been obtained by placing the radiator at the side of the engine. The water pump, with cooling fan and cowling, is mounted on a pedestal bracket off the crankcase with a two-stage belt drive from the crankshaft via the dynamo (Fig. 14). The whole layout of the power transmission unit is well designed; by eliminating the propeller shaft and the rear axle casing considerable weight saving has been achieved. Further savings in this direction have been obtained by the extensive use of aluminium castings for the gearbox, the final drive housing and the cylinder head.

The Fiat "600" is claimed to be capable of a maximum speed of 60 m.p.h., with a fuel consumption not exceeding some 40 to 45 m.p.g., and since its first introduction this spring at the Geneva Saloon, it has already become very popular in Italy and Switzerland. By its interesting conception it may easily stimulate a new approach to the problem of a small, inexpensive and entirely economical light car.

Czechoslovakia was represented at the Show by one new model, the Skoda "Orlik," a 1·1 litre car which in its layout is very much like the earlier Skoda 1·2 litre type. It also has a tubular backbone chassis with independent leaf suspension at the front and at the rear, but a smaller engine. The new power unit of 1·09 litre capacity has the same stroke but a smaller bore than the bigger 36 h.p. engine but develops, with with same compression ratio of 6·5 : 1, 40 h.p. at 4200 r.p.m.

(*To be continued*)

Fig. 12—The water pump and fan of the 633 c.c. Fiat can be seen behind the radiator

Extensions to Bromley Gasworks

LAST week, a new retort house, gas pumping plant and boiler house at the Bromley gasworks of the North Thames Gas Board were officially opened by Mr. L. W. Joynson Hicks, the Parliamentary Secretary to the Ministry of Fuel and Power. The new retort house has increased the gas making capacity of the works by 7,500,000 cubic feet a day, and now, with its total daily capacity of 39,500,000 cubic feet, the Bromley works is the third largest gas-making station in this country.

The new retort house actually went into production in 1954 and the installation of continuous vertical retorts consists of three benches, each containing five settings of eight retorts. Each of the 120 retorts is 25ft long with a major axis of 40in and has a daily coal throughput of 4 tons. The complete installation was supplied by West's Gas Improvement Company, Ltd. The gas offtakes are fitted with liquor sprays and discharge into collecting mains situated just above the level of the setting top. The normal tar and liquor services run from these mains and seals below the retort house governors to a circulation tank and thence to separate tar and liquor storage tanks.

At the end of each retort bench is a battery of four independent brick-set gas producers, and producer fuel brought back to the house from the coke-handling plant is supplied to the producers by a skip fitted with automatic weighing means. Hot producer gas and secondary air are supplied to both sides of each retort bench, and the primary air supplied under pressure by electrically driven fans is saturated by exhaust steam at 15 lb per square inch from the ancillary plant. A Spencer-Bonecourt horizontal waste heat boiler at each bench generates steam at 300 lb per square inch.

Coal of below 2½in is delivered by belt conveyor to the top of the retort house after weighing and sampling for analysis. The coal is distributed from the overhead belt conveyor to the separate benches and the individual retort setting hoppers by travelling throw-off carriages. The coal bunkers, which have a twenty-four hours' storage capacity, are supported independently of the bench steelwork on portal frames, which, with brick cladding, form part of the house structure. The retort bench bracing is spring-loaded and movement of the setting brickwork is controlled by adjustment of the springs.

A coke extraction car, which serves the length below each retort bench, discharges on to a 36in troughed belt conveyor on the sides of the trench, to which are fitted dust exhausting ducts. This conveyor delivers the coke to a buffer hopper, from which the coke passes on to a screening plant. The atmosphere of the house is kept clear of fumes by an extraction plant, which removes hot gases and fumes from the neighbourhood of the retort benches. A cold air douche discharges at ankle level round the top stage ironwork, and coal and coke dust from different levels is removed by a vacuum cleaning plant.

From the retort house the gas is first passed through a boiler feed water heater as a preliminary stage of its primary condensation, and on through three vertical water tube condensers. The gas is pumped through the ancillary plant by one of two steam turbine-driven, single-stage turbo exhausters in a separate house.

The removal of naphthalene and partial benzol removal is effected by oil washing in two multi-stage static washers arranged in parallel. This process is set at this point in order to diminish oil condensation in the ammonia scrubber. It removes about 1 gallon per ton of condensable oils and improves the efficiency of ammonia scrubbing whilst minimising the caking of oxide in the purifiers. After use the washing oil is stripped in a Coppée wet-still benzol recovery plant, and it is expected that this wet-still process will avoid any excessive sludge formation likely to result from the stripping of crude gas.

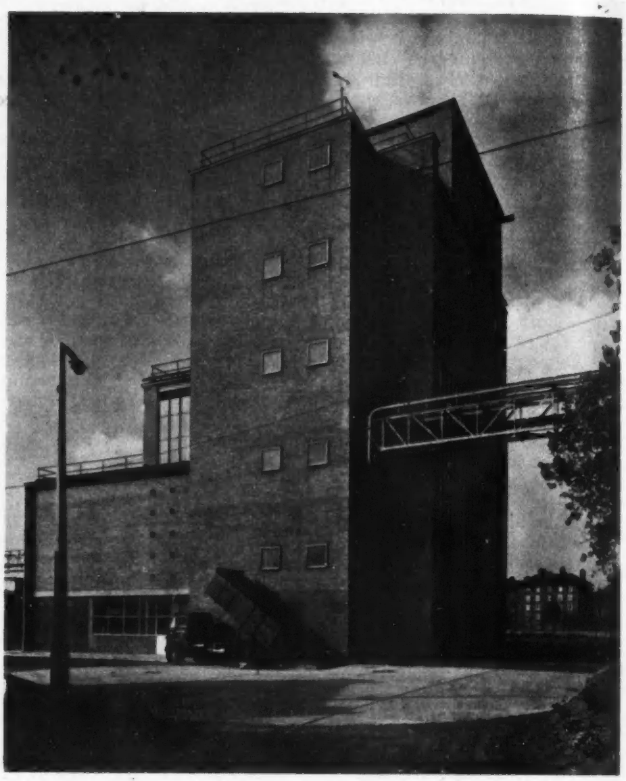
From the partial recovery benzol plant the gas passes to two multi-stage static ammonia washers, in which the washing medium employed is excess weak liquor from the retort house. This liquor flows concurrently with the gas for three bays to increase its degree of carbonation, and then countercurrently.

Final purification of the gas from hydrogen sulphide is effected in a set of six Holmes tower purifiers. Each tower contains fourteen trays, which may be filled with oxide supported on grids in the usual way. As the trays are placed in the tower the central inlet duct is built up and gas enters each tray through slots in this duct, passes upwards through the oxide, and leaves by the gap between the top of one tray and the bottom of the next. By-passing of gas from inlet to outlet is prevented by rubber seals between the inlet gas duct sections of each tray.

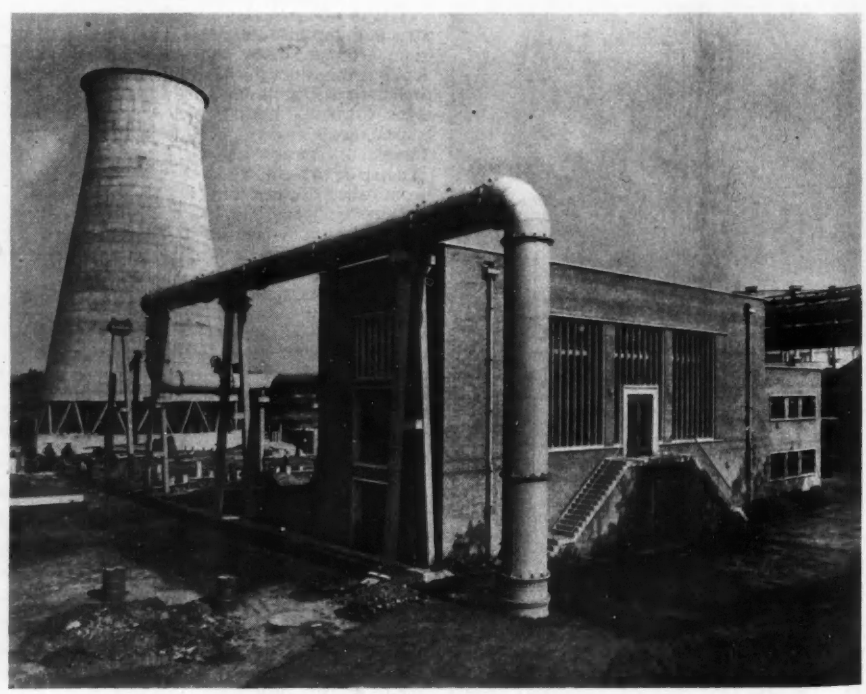
When a tower is due for changing it is isolated, purged and opened, and the individual trays removed by crane and placed in a purged stocking tower. When empty, the tower is refilled with trays of prepared oxide from the non-gas-tight stocking frame. It is then purged from air and put back to work. The whole process takes about ten hours.

The trays containing used material may be removed from the stocking tower at leisure, and the oxide removed by tipping and replaced by fresh material. The prepared trays are then stored in the stocking frame in readiness for the next tower to be changed. The time occupied by this work does not affect the period during which a vessel is off the line. The trays and tower covers are moved by a 35-ton electric travelling crane, which has a span of 56ft. From the oxide hopper a belt feeds the oxide either to lorries or to a portable crushing plant. A mobile conveyor, feeding into a hand-operated revolving chute, is available for filling the trays.

The new boiler-house, which can be seen in one of the illustrations on this page, has three Babcock and Wilcox double drum water-tube boilers installed, each boiler having a normal



New boiler-house at Bromley gasworks



New gas pumping house at Bromley gasworks

evaporative capacity of 15,000 lb per hour at 300 lb per square inch and 650 deg. Fah. These boilers are fitted with chain-grate stokers and are arranged to burn coke breeze with an ash content of about 15 per cent and a water content of about 16 per cent. The travelling grate stoker has compartmental air control and is arranged for the maker's system of gas recirculation for maintaining stable ignition with raw coke breeze. In this system a recirculating fan puts the front end of the stoker under a slight suction to protect the green fuel from cold draughts and facilitate ignition. This fan exhausts to the main forced draught inlet towards the centre of the stoker.

Riddling and fine ash hoppers are installed in the front and central portion of the stoker with a clinker hopper at the rear. Fine ash is dealt with by ejector boxes fitted to the fine ash hopper outlets, the fine ash being discharged into the paddle type main ash extractors.

The dust extracting plant is of the Davidson shunt suction design, in which the primary collector is formed by the fan inlet scroll which concentrates the dust in the gases around the scroll periphery, from which a portion passes to the secondary collector. Here the grit is separated from the gas, which is returned to the eye of the fan. The secondary collector discharges continuously to the dust hoppers, from which the ash is periodically removed to the main ash extractor.

Each boiler has four hand-operated soot blowers, three located in the superheater and the side walls being of the multi-jet type, and one in the front wall of the pilot valve retractable single nozzle type. The economisers are arranged for on-load water washing by a water lance.

The new gas pumping or booster house contains two B.T.H. steam-driven gas pumps, each of 1,000,000 cubic feet per hour capacity. These pumps deliver gas made at Bromley into the western main from Beckton to the grid system against a maximum outlet gas pressure of 120in W.G. The building will also house two existing Allen-Bryan Donkin steam-driven pumps, each of 1,500,000 cubic feet per hour capacity at a maximum outlet gas pressure of 100in W.G., which will pump gas into a medium-pressure main supplying the northern and Hornsey districts. These pumps are all operated by condensing turbines working at 300 lb per square inch and 650 deg. Fah., complete with a natural draught cooling tower.

3300 H.P. Diesel-Electric Main Line Locomotive

In our issue of October 21st, page 571, we gave a brief description of the 3300 h.p. "Deltic" diesel-electric locomotive which has been developed by the English Electric Company, Ltd., for main line passenger and express freight duties. Some further details of this C_0-C_0 locomotive, with its power-to-weight ratio of 72 lb per horsepower and axle loading of 18 tons, are given below.

THE 3300 h.p. diesel-electric locomotive illustrated in Figs. 1 and 2 is powered by two eighteen-cylinder, two-stroke, Napier "Deltic" diesel engines, each driving its own 1080kW, 675V, 1500 r.p.m. generator, and was designed and built by the English Electric Company, Ltd., to operate fast passenger and freight services. As can be seen from the accompanying table, giving the main particulars and dimensions of the locomotive, the two engines provide a continuous tractive effort of 31,000 lb at 33 m.p.h., and a maximum service speed of 90 m.p.h.

The locomotive is designed and built around the two "Deltic" engines which are mounted symmetrically, with the non-driving ends facing inwards, in the long central compartment of the locomotives. In the centre of this compartment, between the two engines, is the train heating boiler. At each end of the central engine compartment is a driving cab and beyond that is a nose compartment containing the air compressor and vacuum exhauster, traction motor blowers, generator resistors, brake equipment, reservoirs and other control equipment.

The train heating boiler is designed to evaporate 2000 lb of water per hour at 80 lb per square inch. Sufficient water for about four hours' operation of the boiler is carried and a bi-directional water pick-up device is fitted to enable the water tanks to be replenished from water troughs whilst the train is moving. A storage battery, used mainly for engine starting, is also housed between the power units, one-half of it being placed against either side of the locomotive. Control cubicles at each end of the engine compartment form the rear bulkheads for the drivers' cabs.

The mechanical parts of the locomotive are generally of orthodox design. Each of the three axles on both the bogies is driven by a traction motor and the bogie is centrally pivoted with respect to the locomotive frame and superstructure. The equalising beams are below the axleboxes. Tanks for fuel and boiler feed water are carried on the underframe between the bogies. Extensive use of aluminium alloys is made in the locomotive superstructure, including roof purlins and panelling.

There are removable roof sections over the engine generator boiler compartments and over each nose compartment, giving access for maintenance, the intention being that the engine generator units can be removed for servicing and the replacement unit installed in an eight-hour shift. The main intakes for the generator cooling air are in the roof sections over the generator.

The roof above the engine houses the radiators and fans for the engine coolant and lubricating oil; there are two pairs of radiator fans, each pair being driven by the engine with which it is associated. Besides covering the silencers the roof over the boiler accommodates the filtered air intakes for the engines and the boiler fire.

Leading Particulars of 3300 h.p. "Deltic" Diesel Electric Locomotive

Diesel engines	Two eighteen-cylinder Napier "Deltic" two-stroke
Rating	3300 h.p.
Axle arrangement	C_0-C_0
Tractive effort, maximum	60,000 lb
Tractive effort, continuous	31,000 lb at 33 m.p.h.
Maximum service speed	90 m.p.h.
Number of traction motors	Six
Weight in running order	106 tons
Overall height from rail level	12ft 10¼in
Overall width	8ft 9½in
Length over buffer beams	66ft
Bogie rigid wheelbase	14ft 4in
Length between pivot centres	44ft
Maximum axle load	18 tons
Minimum curve negotiable	6 chains
Fuel capacity	800 gallons
Water capacity for train heating	600 gallons
Brakes	Air on locomotive, vacuum for train

The "Deltic" engines installed in the new locomotive are traction versions of the engine which was fully described in our issue of April 24, 1953, pages 597–598. For traction duty each of the engines is down-rated to about 1650 h.p. at 1500 r.p.m. (compared with 2500 h.p. at 2000 r.p.m.) to increase the periods between overhauls. The power-to-weight ratio is 6 lb per horsepower.

One of the engine units with its generator and exciter is illustrated in Fig. 2. Briefly, it is an opposed-piston, water-cooled compression-ignition engine, working on the two-stroke cycle and using a centrifugal scavenge blower. The eighteen cylinders are arranged in three banks of six, forming, in the end view, an inverted equilateral triangle, whence the engine derives its name. At each apex of the triangle there is a crankshaft and the three crankshafts drive the main output shaft at the centre of the triangle, through a train of gears. The main output shaft of the engine is solidly coupled to the armature shaft of the generator. A tributary gear train drives an auxiliary output shaft at 1·68 times the engine speed and drives the auxiliary generator and the radiator cooling fans. For starting the engine the main generator is motored, taking power from the storage battery.

With reference to Fig. 2, the assembly of three cylinder blocks and crankcase is held together by long high-tensile through bolts. Each cylinder block is fitted with "wet" liners. In each cylinder one of the opposed pistons controls the exhaust ports and the other the inlet ports; the clearance volume between the two pistons forms the combustion chamber. On the plain rod of

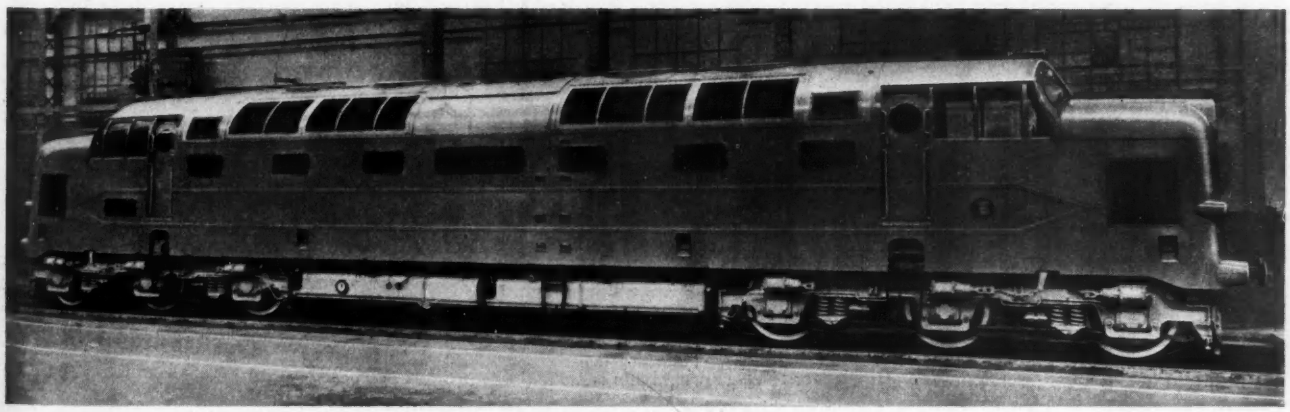


Fig. 1—The "Deltic" 3300 h.p., C_0-C_0 diesel-electric locomotive illustrated here is driven by two Napier "Deltic" engines. It has a maximum service speed of 90 m.p.h. and is intended for main line passenger and express freight duties

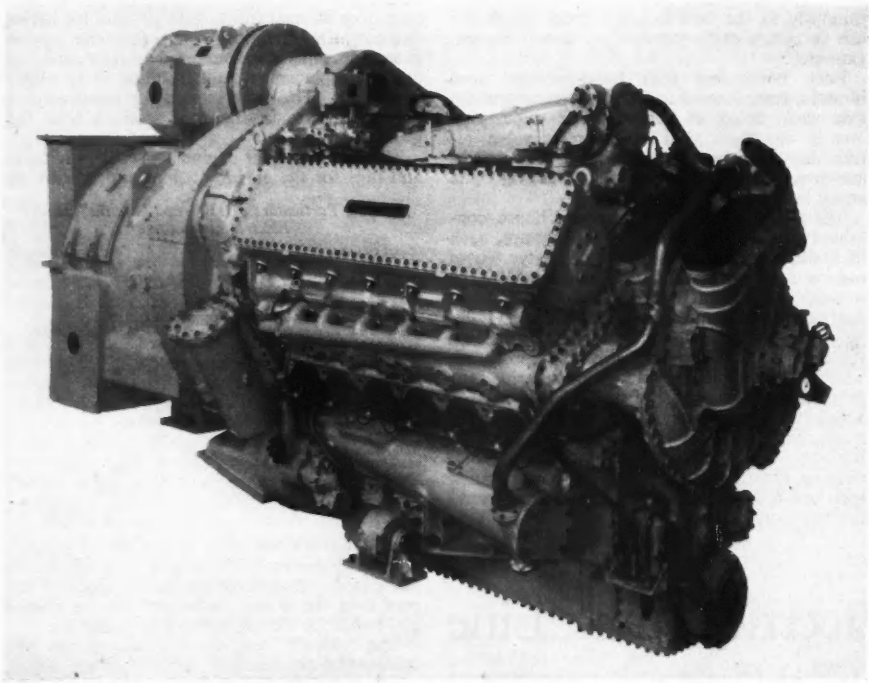


Fig. 2—The "Deltic" eighteen-cylinder, opposed-piston, water-cooled diesel engine operates on the two-stroke cycle. The cylinders are in three banks of six, forming in end view an inverted equilateral triangle. The main and auxiliary generators are on the left

each crankpin is fitted an inlet piston of one cylinder bank and on the forked rod is fitted the exhaust piston of another bank. The two upper crankshafts have identical throws, while the cranks on the bottom shaft are of opposite hand to suit the direction of rotation.

At the free end of the engine is the centrifugal scavenge blower; it is driven from the phasing gearing by torsionally flexible twin shafts running through the cylinder blocks.

Both the fuel and lubrication circuits are provided with full-flow filters. Each bank of six cylinders is individually served by a variable-delivery fuel injection pump, which supplies fuel under pressure to the injectors. An engine-driven fuel circulating pump maintains a pressurised fuel supply in excess of engine requirements and the surplus is returned to the service tank through a pressurising valve.

The engine is lubricated by the dry sump system, oil from the storage tank being supplied by the main pressure pump through filters to the crankshafts and the principal engine bearings. Scavenge oil from the sump is drawn by a scavenge pump through a chip strainer and is returned through a heat exchanger and a thermostatic valve to the tank, for recirculation. Oil is supplied by auxiliary pumps to sparge jets to lubricate the meshing points of the gears and the blower bearings. From the main pressure oil system some oil is tapped and supplied at reduced pressure to subsidiary bearings and to the blower drive gear trains.

Cooling is effected by a closed circuit system using fresh water containing a corrosion inhibitor, and the heat is dissipated in an internal heat exchanger controlled by a thermostatic valve and by-pass circuits.

Normally, both engine generator sets will run together, each engine being controlled independently by air pressure actuators operating the governor mechanism. The engine torque is automatically adjusted to the load and speed setting. Although the two engines are independent units the two main generators are connected in series so that they must carry the same armature current. The output of each generator is made to match the available horsepower of its driving engine at all speeds by automatic adjustment of the generator excitation. This condition is achieved through limit switch contacts associated with the engine governor. Any change in engine speed causes these contacts to actuate a reversible split-phase motor which operates a regulator and alters the excitation of the main generator in such a sense that the generator output will match the available engine power. Automatic continuous power control is thus provided at all engine and locomotive speeds.

The six traction motors are connected in three parallel groups of two, the whole motor load being supplied, as mentioned above, by the two generators in series. Change-over switches are fitted so that all six traction motors can be supplied by either engine generator set. With only one set in operation the locomotive can therefore maintain its tractive effort by operating at approximately half speed.

Automatic field weakening of the motors in two stages is provided. This facility can be cut out, however, for certain traffic conditions, such as the hauling of heavy loads at slow speeds (unbraked freight trains) when the traction motors would be operated with full field only.

Technical Reports

The Design of Bituminous Road Compositions. By A. R. Lee. Technical Note No. 2. British Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3. Price: free.—The report provides a detailed account of test procedures for the design of bituminous road compositions, giving attention, in the last section, to the use of rubberised bitumen. It should, therefore, arouse special interest at a time when the Road Research Laboratory is carrying out a further series of full scale experiments with rubberised materials. The report is illustrated with a dozen photographs and diagrams. The subject headings are: "Surface Dressings," "Open Textured Macadam Surfacings" and "Dense Surfacings." Most of the data given is based on road work, the author considering that the only reliable test for bituminous surfacings is the full scale road experiment.

Investigation of Deterioration of Moulded Carbon Resistors: First Report (Ref. Z/T92). By H. F. Church and J. J. Walsh. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—This report describes briefly the results obtained during the first twelve months of a research programme to study the deterioration of moulded carbon resistors. The main work may be divided into two parts: (*a*) a general study of the mechanism of conduction, and (*b*) life test investigations. These are reported separately, but were carried out concurrently. Altogether some 350 resistors have been or are under life test. A resistor noise measuring set has been designed and built but noise measurements on the resistors dealt with in this report have not yet been made.

Institution of British Agricultural Engineers

THE opening meeting of the new session of the Institution of British Agricultural Engineers was held in London on Thursday of last week, when Mr. D. R. Bomford was installed as president in succession to Mr. D. P. Ransome. In his presidential address, which was delivered at the meeting, Mr. Bomford dealt with the progress of agricultural mechanisation during the present century. A notable factor in that progress, he said, was that agricultural mechanisation in the twentieth century had taken place in two stages. They were the mechanisation of "horse work," which had made "horseless" farms possible, and, at a higher level of achievement, the more difficult mechanisation of hand work which was the target of most development workers to-day. Mr. Bomford went on to say that the first problem which the development worker must solve was to find out the farmer's requirements. It was not easy for the farmer to forecast correctly his own requirements, and it was still more difficult for the engineer unless he was in the closest possible contact with the farmer's opinions. It was in the nature of things, Mr. Bomford continued, that this forecast of requirement should become increasingly difficult as mechanisation progressed, and it was not easy to-day to find many farm processes which had not been at least touched by mechanisation. Mechanisation had been defined as the substitution of mechanical power for power provided by human or animal muscle. In every case where machine power had been applied, Mr. Bomford said, there was scope for its more efficient application. That kind of development work, he added, was less spectacular than the initial application of power, but it was none the less of value to the farming industry. This improvement in the application of power, Mr. Bomford urged, was an objective that would always be available to the development worker. At the conclusion of the address, the first award of the Johnson medal was made to Mr. R. C. Trendall, who has been adjudged the most outstanding candidate at the fifth examination for the National Diploma in Agricultural Engineering. The presentation was made by Lieut.-Colonel Philip Johnson, the Institution's founder-president, in whose honour the medal has been struck.

Mr. E. G. King

IT is with regret that we have to record the recent death of Mr. Ernest Gerald King, chairman of the Louis Cassier Company, Ltd., a subsidiary of Associated Iliffe Press, Ltd. Mr. King, who was seventy-eight, entered journalism in 1894 when he joined the London staff of the American engineering and shipbuilding journal, *Cassier's Magazine*. When Mr. Louis Cassier died in 1906, Mr. King acquired control and became managing director of the company. In the years that followed other journals were introduced by the company, including *Metal Industry*, *Iron and Steel*, *Welding and Metal Fabrication*, and *Machine Shop Magazine*. In 1930 it was decided to change the name of *Cassier's Magazine* to its present title, *Mechanical Handling*, as Mr. King felt that developments taking place in the United States in this field were certain to develop equally in this country. The control of the company was handed over to the Associated Iliffe Press, Ltd., in 1942. Mr. King's death will be deeply regretted by a wide circle of friends both in journalistic circles and in industry.

Jet Flap

By I. M. DAVIDSON, B.Sc., A.F.R.Ae.S.*

No. II—(*Concluded from page 619, October 28th*)

At the Royal Institution on Thursday, October 20th, a paper to the Royal Aeronautical Society on the subject of the jet flap was presented and illustrated with a film. We print below abstracts from the paper and discussion.

Wings of Finite Span

About jet flapped wings of finite aspect ratio very little is known, although, ironically enough, the only available results are those obtained before the second world war by Hagedorn and Ruden[4] with the model illustrated in Fig. 19. Not only is this believed to be the first jet flap experiment ever conducted, but the authors correctly diagnosed the active principle in the following words:—

"... with blowing there will be a pressure difference at the trailing edge—unlike the case with zero jet speed. The pressure difference

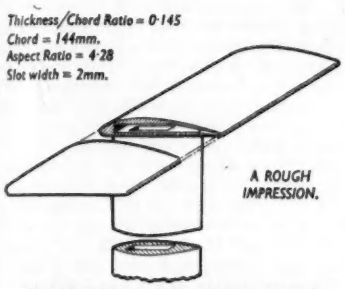


Fig. 19—The first jet flapped aerofoil

across the jet stream probably decays only gradually in the downstream direction and this is the force responsible for curving that stream until it is parallel to the undisturbed mainstream. The pressure distribution on the aerofoil consequently becomes more rectangular and the lift therefore increases."

However, since the tests were done only during the calibration of a model intended for work on boundary layer control and, presumably, since jet propulsion was then a thing of the future, those early results were never followed up. Nor was there reported any thrust-drag information, pressure plotting, or flow study.

Although the reaction lift of a real jet flapped wing cannot be affected by its three-dimensional nature, the total rather than the pressure lift must be the cause of the induced incidence, for even the reaction lift is felt by the mainstream in the form of a pressure difference across the jet sheet. Hence, very nearly, but not quite, the conventional formulæ will be used in correcting the pressure lift for the effects of aspect ratio. If it be imagined for simplicity that the wing sheds a conventional tip vortex, this will be partly, if not completely, entrained by the jet, to which it must impart its angular momentum. Hence, since at high C_J values the jet will be moving very much faster than the mainstream, the result will be a reduction in the magnitude of the usual induced negative incidence.

In practice, of course, the shed vorticity will go more or less directly into the jet, so that it will never really appear as a tip vortex and an alternative view is perhaps the best. This is that all real wings generate their lift by throwing down the mainstream, so that, if through its entrainment action a jet flapped wing can get to grips with more than the usual mass flow, it must throw it down at less than the usual angle. With its relationship to the Froude efficiency of propulsion, this argument suggests also why the induced drag of a jet flapped wing will be substantially less than that of a conventional wing with the same conditions of loading. Just how much less it is not yet possible to say.

Some Aeronautical Considerations

Before the jet flap principle can be applied properly much of the theory and practice of low-speed flight must be written anew, for, aerodynamically speaking, the situation is akin to that which prevailed in or about the year 1900. With technology as it now stands this may not, of course, take long, but, for the present, it would be foolish to attempt any prediction concerning the aircraft types which will emerge. So far, the horizon is just nowhere in sight.

Nevertheless, in pursuing the opening theme it remains to be shown that a practicable aircraft can be constructed around the principle, and for this exercise some sort of model is clearly necessary. Thus, although sketched as realistically as circumstances will allow, I can only hope that this example will be accepted as a first-simple expedient.

The *de novo* Approach

The analogous flap size for a typical aircraft of, say, the "Comet" calibre is illustrated in Fig. 20, which suggests that in cruising flight the machine could be regarded simply as a conventional aeroplane. In low-speed flight the situation is not so obvious, for, although there is now a rough working knowledge of the properties of a jet flapped wing, little has been deduced about the likely behaviour of a whole aircraft. One thing, however, is certain—that in flight through still air the maximum C_L value will be determined solely by the available thrust, and that it will be very large indeed.

For example, in landing trim this machine might display a wing loading of 55 lb per square

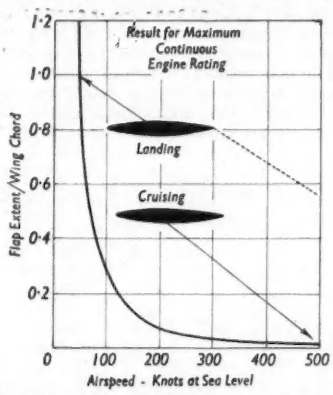


Fig. 20—The analogous flap size for a typical air liner

foot, and, with fully developed by-pass engines a jet reaction to aircraft weight ratio of about 0·55. With no contingency allowance and with a jet angle of some 40 deg. even this quasi-conventional aircraft would be off the present experimental map, but a slight extrapolation suggests for it an approach speed of 35 knots at a total lift coefficient of about 13½. The low-speed problem is thus mainly that of so designing the machine that, with all due allowances for engine failure, gusts, baulking and human error, and so on, the ideal still-air performance can be approached as closely as possible. That is, of course, the common problem of all high lift aircraft, but with the jet flap there exist two novel and potentially powerful possibilities:

(i) There is in principle a chance of making the aircraft unstallable.

(ii) Due to the inherent lift-thrust coupling, it should be possible to control far below the minimum drag speed.

However, in striving for these characteristics it is found that not only the lift, but also all its controlling increments must be generated aft of the effective mid-chord point, and this suggests that the conventional elevator system be abandoned. So far as the pilot is concerned there could be a perfectly conventional cockpit layout and the rudder would follow normal practice, but the tailplane would be fixed, while the jet flap would assume the functions of the elevators, ailerons, flaps and air brakes.

In practice the flap control might lower the jet through some 30 deg. to 40 deg., while at the same time trimming the one-piece tailplane to an appropriate downwash angle. On top of this, the control column would provide at all times a vernier action of plus and minus a few degrees, the jets on either side of the fuselage acting together as elevators and differentially as ailerons. Finally, the jet would be divided into a number of continuous spanwise sections, adjacent elements moving differentially about any common datum for the purpose of generating induced drag independently of the overall lift.

The Shrouded Jet.—In practice, this scheme entails with a pure or simple jet flap two quite unacceptable snags—the responsibility for the aircraft control system must be handed at once to its engine designer, while the very survival of the craft clearly depends upon the unfailing operation of its power plant. These difficulties can be overcome by the introduction of a small hinged flap or jet shroud as illustrated in Fig. 21. The term shroud arose because the arrangement was originally conceived only for the control of the jet and the reduction of its entrainment

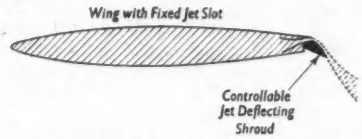


Fig. 21—A practical embodiment of the principle

drag; but since then, the appendage has been found to offer so many engineering advantages that its atrophy now seems unthinkable.

In operation the jet follows the shroud by what is commonly termed the Coanda effect[12] and, with a little care, there is no difficulty in turning any sort of jet through 90 deg. and more. The best shroud size will vary from one design to another, for it depends upon many diverse factors; but typical values might lie in the range from 3 to 10 per cent of the wing chord, with a bias towards the lower figure.

Since the lift from a small flap varies as the square root of its chordal extent, the effects of the shroud and jet will clearly not be additive. One approximate theoretical result suggests, for example, that while the separate C_L values from a 5 per cent shroud and a jet of C_J value 1·0, may be respectively 1·8 and 5·4, they will yield in combination only 6·1. Thus, while the shroud will be all-important in cruising flight, it can, with perhaps one exception, be neglected in first order high-lift calculations. The exception is its effect on the centre of total lift, and this could be important because it makes possible a reduction of the unusually large tailplane volume coefficient.

Static Stability and Control.—This large tail volume may prove embarrassing, since it implies, of course, extra drag and structure weight. The difficulty arises because, as in Fig. 22, the aircraft centre of gravity will be in the vicinity of its mid-chord point, so that the distance between the aerodynamic centre of the wing and that of the whole aircraft—that is, the neutral

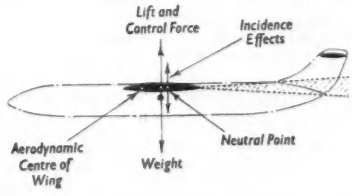


Fig. 22—The general arrangement for control without incidence

point—must have about twice its conventional value.

In high-speed flight the equivalent of elevator control will be a movement of the shroud, so that the controlling lift increment will be generated close to the mid-chord point and the response will be a ballooning of the aircraft with the tailplane serving purely as a weathercock to pitch it into the resulting climb.

In low-speed flight with a high aspect ratio and the tailplane properly trimmed, the balance of forces should be as in Fig. 23. Its centre of lift having moved aft, the wing will exhibit at zero incidence a large nose-down pitching moment about the centre of gravity. This will be balanced partly by the upwash and downwash couple on the fuselage and partly by under-trimming the tailplane, but also by the whole machine adopting automatically a nose-down

* National Gas Turbine Establishment.

equilibrium attitude. With sufficient of this third ingredient it is clear that the more lift the pilot applies the farther does the craft move from its stalling incidence—hence the possibility of an unstallable aircraft.

Some Three-Dimensional Effects

Since the jet flapped aerofoil is so insensitive to upper surface separation effects it may well prove a cure for many of those vices which are commonly associated with sweepback. Hence, in a first look at the three-dimensional picture,

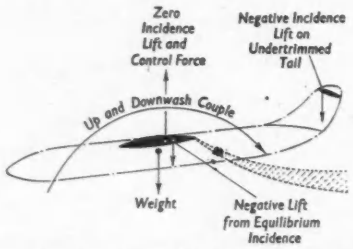

Zero Incidence Lift and Control Force
Negative Incidence Lift on Undertrimmed Tail
Up and Downwash Couple
Weight
Negative Lift from Equilibrium Incidence

Fig. 23—The balance of forces in low speed flight

we can safely afford to omit plan form in favour of aspect ratio.

Two-dimensionally, it has been suggested that the aircraft should be designed to adopt in low-speed flight a small negative incidence. In practice the argument remains, but the nose-down attitude will be struck relative to the downwardly induced mainstream rather than to the flight path. Hence, while the static stability of the machine will be unimpaired, its attitude relative to the flight path will be one of such a positive incidence that, to a first order, the two-dimensional lift and centre of lift will be obtained independently of the aspect ratio.

In the last analysis, the crucial requirement for good low speed handling is that, without throttle adjustment, an increase in C_L should produce a sustained increase in the angle of climb. For any machine controlled by elevator movement this condition defines the minimum drag speed, but for a jet flapped wing controlled through its throttles the handling limit is very much lower ; indeed, it is well below the speed at which level flight is possible.

The reason is that, since the machine would land in a fully streamlined condition, its profile and parasitic drags will be so small that, in a first analysis, they can be balanced against the rate of descent and forgotten. Thus, while the thrust will be equal to the sum of the induced and jet drags, these three all increase directly with C_L^2, so that any throttle adjustment will vary the lift without disturbing the thrust-drag balance.

Hence, in practice the pilot can use his throttles as a rate of descent control which produces no first order change in the air speed or attitude of the craft.

Some Factors Affecting the Maximum Lift

Since the two-dimensional experiments have disclosed significant ground interference effects, it might reasonably be supposed that, during the take-off and landing, these would cause some embarrassment. No assessment is yet possible, but observation suggests that the effects are of the same order as, but in the opposite sense from, those which normally occur due to the suppression of three-dimensional effects, so that in the long run the overall disturbance may prove trifling.

Gusts.—While little enough is known about the sort of gusts which will be encountered, virtually no information is available concerning the likely dynamic response of a jet flapped aircraft. The one established fact is that the lift on a jet flapped wing varies not as the square of, but directly as, its flight speed. Hence, for given loading conditions, a horizontal gust will have much less effect than it would on a conventional machine.

Were one wing to drop in a gust, a natural reaction would involve the application of opposite aileron, which produces a differential movement of the jets on either side of the fuselage. Thus, both the induced and jet drags would increase on the dropped wing while decreasing on the other so that, as the machine regained an even keel, it would turn markedly off course.

With all engines intact in still air such an incident could not, of course, arise, for any required lateral or directional correction would be made as a slow, fully co-ordinated manœuvre. Thus it is evident that one way in which atmospheric turbulence might limit the maximum lift is through the creation of lateral handling difficulties which are analogous to those that occur with a conventional aircraft well below its minimum drag speed.

The probable stability effects are at first sight more serious, for although the pilot cannot stall the aircraft, the encounter during a 40 knot approach of even a moderate upgust must be presumed to cause trouble. However, the situation is by no means as bad as it looks at first sight for, apart from two obvious evasive design measures, the stall may itself transpire to be relatively innocuous.

The first measure is applicable only to highly powered aircraft of moderate aspect ratio on which the three-dimensionally induced negative incidence might be 20 deg. or more. With plenty of thrust in hand, it could pay to accept, say, 10 deg. of this to yield on the one hand a reasonable landing attitude and on the other an inherent anti-gust margin.

On a high-speed aircraft the aspirated air velocity will be some 700ft or 800ft per second, and this suggests the second measure for, in low speed flight, it would correspond to an extremely high suction in the intake plane. Thus the intake system could comprise a continuous, full span, leading edge slot, such that the stalling incidence of the wing is substantially increased.

Superficially, this arrangement closely resembles a well-known system of leading edge

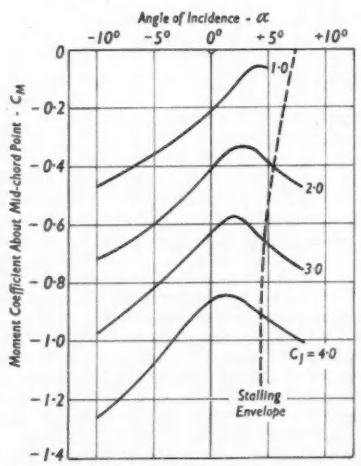


Fig. 24—Stalling stability of 31·4 deg. model

boundary layer control, but the likeness is misleading ; for one thing, the aspirated flow is vastly greater than that in the boundary layer. This arrangement might indeed prove a logical and important move in the aerodynamic synthesis of the aircraft for, since the small intake width could lend itself to the installation of an unusually efficient diffuser followed by low duct velocities, there need be little or no resulting intake loss penalty.

However, not all aircraft can have buried engines ; the majority are and always will be propeller-driven, and for these the jet flap principle will be no less important than for their better integrated brethren. Naturally, there is always the possibility of conventional leading edge boundary layer control ; but also there is a more economic alternative. When the long upper surface bubble finally bursts to form an open wake the lift loss must clearly be confined to its induced component, which acts well forward of the aircraft centre of gravity. Thus, even with a two-dimensional aerofoil it is to be expected that the stall will be accompanied by a substantial restoring moment, and such a result is quite evident in the curves of Fig. 24. With a complete aircraft the effect will be even more pronounced due to the loss of downwash on the rear fuselage and tailplane, so that in practice the stall may well constitute a handling problem rather than a hazard.

Although the aircraft may thus take care of itself in pitch there remains the difficulty of the dropped wing. At this point major dynamic effects must be presumed to cloud the picture, but there can be little doubt that, in the presence of an ample thrust reserve, safety can be guaranteed at the expense of spoiling the approach. However, to keep things in perspective, it should be remembered that the object of the exercise is not to line up with a runway at, say, 120 knots, but to drop into a cabbage patch at 40 knots or less.

Engine Failure.—As with gust behaviour, the precise allowances which must be made to guard against engine failure cannot yet be assessed, and may emerge only after much flying experience has been accumulated. However, since this contingency is even more amenable to design treatment, it is well worth looking at a few cardinal principles, the first question being what happens when the fuel runs out ?

In modern practice the forced landing is commonly to be dreaded, but with the sort of speeds now under consideration and an all-up weight of 100,000 lb or so, there is clearly every hope of a safe descent even in a mountainous or well-populated terrain. Thus, it would be utterly illogical not to carry in an emergency system the five minutes fuel which would be required for air-braking and crash landing purposes after a long, unpowered glide from altitude.

In the more likely event of an engine cut during take-off or landing, there are two main points to be watched. The first is that the most embarrassing consequence will be neither the loss of thrust nor the loss of lift, but rather the yawing and rolling moments which must be checked immediately after the incident. The second is that there is no fundamental difficulty, but only an economic one ; for the necessary thrust margin will depend primarily on the number of engines employed and the skill of the designer.

In returning once more to the example, there might be eight identical engines each powering one-eighth of the wing area, and all of these, being by-pass units, would be required for the cruise.

Ideally, the exhausts would be pooled entirely or in groups, but for several obvious reasons this temptation must be resisted. Although it is reasonable to insist that the control system shall cope with a failure of any one of the six inboard engines, it cannot be expected to handle a single outboard failure. Hence, the outermost engines would have cross-coupled fuel systems—rather like a Ward-Leonard set—so that whatever happened they would run down together.

Now this powered wing incorporates two essential aerodynamic ingredients—the jet flap itself and the fully integrated, anti-gust intake. While the former may be allowed to fail the latter cannot, and so part of the wing must be used as a transfer duct which connects each engine through its non-return intake valve to the common intake slot. Structurally, very little of this cold, low pressure ducting need be parasitic and, as illustrated, it would transport the air at little over 200ft per second.

To reduce to a minimum the overall disturbance following an engine failure, the shroud must clearly be made to do as much work as possible. For example, when a 5 per cent shroud is compared at the same angle with a pure jet of C_J value 2·0, it is found to yield fully one quarter of the lift of the latter. However, in the event of engine failure the unblown shroud would be assisted by the overlapping fields from the neighbouring jets, so that the panel lift would drop not to a quarter, but perhaps only to a half. For this to be possible, however, the shroud itself must be unstalled, and this can be ensured by means of a cold, boundary layer controlling sub-jet which is fed through a manifold supplied by all eight engines.

Some Future Possibilities

Having concocted such an arrangement one naturally estimates what it will do, for, even with the present state of knowledge, probable orders of magnitude can be discussed. For long range operation the machine might have an all-up weight of 150,000 lb, a sea level static thrust of

60,000 lb, and a gross wing area of 2000 square feet, with an aspect ratio of 6·0. Then, to yield complete safety with the failure of any one of the six inboard engines, or of both outers, a climb-out speed of about 80 knots would be used. In the event of such a failure the conventional 50ft screen might then be cleared in 500 yards whilst, on all eight engines, the corresponding figure would be just over 350 yards.

For a landing weight of 110,000 lb, 35 knots has already been suggested as an ideal minimum figure, but this permits of no contingency allowance. With an approach angle of 6 deg. and an attitude of 9 deg. or 10 deg. relative to the ground, a speed of some 50 knots would apparently cope with simultaneous baulking and engine failure, while the landing distance from 50ft clearly need not exceed 500 yards.

Since this sort of thing is immediately possible, what about the future? Again, while any recognisable forecast would be imprudent, certain possible trends can nevertheless be discerned. To take one example, there is the possibility of paring down that margin between 50 and 35 knots, for, at the latter figure, a city-centre airport is conceivable even for the 500 knot trans-oceanic aircraft. On the engine side this demands a lessened penalty for failure and, since the eight engines each have four separate cylinders, much could be gained by the judicious interlacing of fuel systems.

Then there is the possibility of using the jet flap principle on propeller-driven aircraft so as to make full use of the slipstream, and in several respects this type of application seems even more promising than that to the pure jet-driven machine. This is feasible in principle because, under take-off conditions, many turbo-prop engines yield about twice the power which they do in normal cruising flight. These days most of that extra take-off power goes to the propellers, but it requires no more than a variable area exhaust slot to extract it instead as additional jet thrust.

There is still, however, the gust handling problem and this raises a possibly impractical, but nevertheless fascinating, idea. In the bird, control is achieved through a nervous system which determines not only the magnitude of its lift and thrust, but also their spanwise distribution. In a typical jet flapped aircraft there may be eight propelling engines, each with its own length of shroud which is capable of producing almost any lift-thrust or lift-drag combination independently of the other seven wing panels. No human pilot could ever hope to make use of this facility, nor would the assistance of the thermionic valve be an economic proposition but, with the coming of the transistor, may not such an aircraft be given ultimately a nervous system of its own?

Conclusion

In this lecture I have attempted to cover a great deal of ground, perhaps too much, but even so it has been possible to mention only a tithe of the discoveries in this new and rapidly expanding field. In fact, I have limited myself to the work of the original National Gas Turbine Establishment team, of which the other members were Dr. B. S. Stratford and Mr. N. A. Dimmock.

To them, I would gladly acknowledge a substantial debt, for without Stratford's theory, Dimmock's experiments could not have been designed and, without those, there would clearly have been no lecture.

Discussion

Professor E. J. Richards: For the engines of the future we can expect fluctuation pressures, noise, if you wish, in our jet of as much as ½ lb or ¼ lb per square inch. As that will occur at frequencies of, say, 200 cycles, it means we shall be getting a million reversals in about an hour. The problem of structural effect and stress in the aeroplanes will be great. It is interesting that on a scheme like yours, on which the jet is being used much more spread out, we can expect noise reductions of 10 db or even 20 db. That is to say, the pressures will give us one-tenth or even one-hundredth of the figures mentioned.

Mr. Davidson, in reply: Professor Richards pointed out that the noise would be reduced. I did not put it in the paper because at the time of writing it was a pretty controversial—indeed, one might say, political—issue. One small point he did not bring out is that as well as the reduction in the decibel or noise level, the noise will be pushed right up the frequency spectrum, so that we can expect quite a change to follow from that.

We would naturally envisage as much change in the engine as we would envisage in the aircraft. The sort of change we should perhaps see would be a marked reduction in jet temperatures through the use of by-pass engines or engines of that ilk. This would bring about a lower jet speed and, as we all know, the noise goes down as something like the ninth power of jet speed.

Dr. G. V. Lachmann: I can follow Mr. Davidson quite well as far as the two-dimensional wing is concerned. As far as the three-dimensional wing is concerned, I should like to ask some questions, although I appreciate that this idea of the induced drag of the three-dimensional jet for the wing is apparently only in the stage of an inspired intuition.

In paragraph 2.2 it is stated that:

"When $\rho_j V_j > \rho_0 V_0$ there is jet drag; when it is smaller there is an analogous thrust and, as it happens, the value of $\rho_j V_j$ in cruising flight approximates closely to $\rho_0 V_0$ for most practical aircraft, whether they be propelled by simple jet, by-pass or ducted fan engines."

Therefore, at least in cruising flight, one would not expect any single effect of entrainment and, therefore, no reduction in C_L^2. When $\rho_j V_j$ is larger than $\rho_0 V_0$ there is a possible reduction of induced drag due to the same effect of entrainment and that is on the credit side. But there is an increase of jet drag on the debit side. When $\rho_j V_j$ is smaller than $\rho_0 V_0$ we have an increase of induced drag which has a serious effect and an increase of jet thrust on the debit side.

One wonders whether in this aerodynamic bookkeeping there will be a profit in the end or whether this profit will only be imaginary.

Referring to the hypothetical layout, one wonders where the fuel goes. There seems to be very little space for the tanks and the proximity of the fuel and hot ducts does not seem to be a practical solution.

Mr. Davidson: When I introduced all this nomenclature of $\rho_0 V_0$ and $\rho_j V_j$ I was afraid you would get all tied up. I have got tied up and I cannot understand this question. But I think I can still answer it! (Laughter.) You will see in a moment that I have several little tricks up my sleeve.

First, we have not made any mention of what happened to the aircraft boundary layer except under very high lift conditions where we could not care less. On the cruise, if you will wait long enough to see Dr. Stratford's paper, you will see that a lot of interesting effects are possible. These mixing processes can remove in theory the forward drag on the wing.

I agree entirely with Dr. Lachmann that there will be no reduction in induced drag under cruising conditions, and I am sorry if I gave that impression in my paper. I was really talking about the take-off and landing case where the whole secret of getting the maximum lift is to get the minimum induced drag, because you need all the thrust you have to push the aircraft along. So far as the cruise is concerned, I should not like to go into details except to say there are these boundary layer control effects and the overall account book will, I think, look very much like that for a conventional aircraft. We shall have more structural weight in some places and less in others, a bit less thrust because of internal losses, but possibly a bit less drag.

Concerning fuel tanks and engines, I confess that this is a difficult problem, but I only put this example forward as the sort of thing we should envisage immediately. One of the things I have not discussed at all and one which I am sure Dr. Griffith will delight in is the idea of doing away with the tail and using jet stabilisation. But if we do that, we do not know whether our aeroplane is going to have wings and a tail or whether it is going to be a flying saucer. All we need is a large area on which to induce lift and the means of stabilising. There are several ways of stabilising, and we have not looked sufficiently far ahead to take them all into account, so at the moment where the fuel and engines will go in the future machine is not worth arguing about.

Mr. L. F. Nicholson: I imagine that one of the dreams of any scientist or research engineer must be to find some new problem on which to work where experiment and theory, backed by insight and imagination, can make great advances rather than in tidying up the details in a field which is generally well understood. Mr. Davidson and his team are, I think, to be congratulated on finding such a problem and also on the brilliant way in which they have seized their opportunity and opened up this new field.

I have a controversial point: that a circle is a pretty natural shape and the engine thrust in cruising flight is really something which must not be compromised seriously in order to get landing and take-off improved. What sort of losses might we expect from forcing our engines to the type of shape, construction and jets of the slits which go with this idea?

Mr. Davidson: On the question of loss on cruise it is difficult to give a firm estimate. In the engine field we have to do our experiments on our internal aerodynamics. So far we have only looked at the point in the field where the aircraft and engine fluids meet. But at a rough guess there is no doubt that we are going to lose something like 10 per cent of our net thrust in cruising flight in internal loss in taking this gas about.

Mr. E. Pribram: I have made an estimate of the layout and I do not agree with Mr. Davidson, making the internal loss nearly twice as much. I would like to know on what basis he estimated that, because the major part is vorticity of current effects.

Mr. Davidson: Concerning the internal loss question, I can only say that at the National Gas Turbine Establishment we are responsible for all gas turbines, whether they are burning aircraft fuel or peat. In investigations relating, for example, to gas turbine power stations, one finds that the losses in the ducting cause the most appalling decrease in overall performance. It is really surprising. They add up to thousands of horsepower in a typical power station layout.

We have gone into this very thoroughly, and it is possible to produce ducting systems that have vastly less vorticity and secondary loss than is commonly employed in ducting systems in industry or aircraft, something like one-fourth or one-fifth the usual defect.

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Pump for Water-borne Solids.—The firm of Arthur Lyon and Co. (Engineers), Ltd., of Stamford, Lincs, is now making a disc pump for dealing with water containing abrasive material, small solids in suspension, mud, &c. The pump is driven by a petrol or petrol/paraffin engine through a worm gearbox and is designed for an output of 1200 gallons an hour, a maximum head of 20ft and a maximum suction lift of 20ft. It has a cast iron pump chamber and the diaphragm and non-return valve are made of rubber interleaved with canvas. The top casing is so designed that a pocket of air is trapped during pumping to absorb shock and even out the pumping rate.

LITERATURE

Ultrasonic Engineering. By A. E. CRAWFORD. London : Butterworths Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 45s.

AT the present time, when there is so much talk of the use and applications of electronics, the word " ultrasonics " has a fashionable flavour. It is, however, the name given to the study of the effects and uses of high-intensity vibratory waves in the frequency spectrum extending from the upper limit of hearing at about 16,000 c/s to a figure at least one hundred times greater. The development of high-power sources of such waves enables a concentrated beam of ultrasonic energy to be obtained, and this may then be arranged to cause particle vibration in solids, liquids and gases. This increase in available power may be said to have transformed ultrasonics from a subject utilised for demonstrations in physics laboratories to a branch of engineering with a wide range of applications in industrial processing of materials. Thus ultrasonic energy may be employed for emulsification in the preparation of pharmaceutical, cosmetic and food products. It may also be used for the drilling, soldering and surface treatment of metals.

Ultrasonic Engineering has the sub-title " with particular reference to high-power applications " and is written from the point of view of the engineer rather than the physicist. It is divided into three sections, theory, generation and applications. The first chapter, which is introductory in character, deals, amongst other things, with refraction, absorption and energy measurement of supersonic waves and lists the various kinds of transducer which produce these waves. The second chapter is devoted to a discussion of cavitation, which is a phenomenon occurring in many supersonic engineering applications.

The section on generation has four chapters. The first deals with piezoelectric transducers and opens with a brief study of the crystals commonly employed ; the methods of applying them to various loads are then discussed, together with circuits by which the crystals may be excited. The second chapter on generation is concerned with magnetostriction devices. A review of the magnetostriction effect is followed by transducer design considerations and methods of coupling them to the load. The next chapter is devoted to jet generators and describes the various kinds of whistles and sirens used in industrial treatment of liquids and gases. High and low-frequency moving coil systems are dealt with in the succeeding chapter on electromagnetic transducers.

The remaining half of the book is given up to the third section on applications of ultrasonic energy. The first three chapters deal with such things as the precipitation of particles in gases, the agglomeration and coagulation of liquids, the separation of gaseous mixtures, emulsification and dispersion, and the role of ultrasonics in the promotion of chemical reactions. A further two chapters are concerned with the application of ultrasonic energy to metallurgical operations and consider also the drilling, soldering and tinning of metals. Ultrasonic soldering irons have simplified the problem associated with the soldering of light metals, such as aluminium, magnesium and their alloys. The two remaining chapters describe respectively biological effects and miscellaneous applications.

The book has been written for engineers and should be of interest and use to those who are, or may be, concerned with the application of ultrasonic waves. The author assumes, as one would expect, that the reader has some background of electrical engineering training and a knowledge of simple electronic circuits. This should not deter other engineers, however, as the book is written in a clear though at times rather brief manner. A very useful feature of the book is the provision of references to the literature at the end of each chapter.

First Congress of the Fédération Internationale de la Précontrainte. London, 1953. Published by the Cement and Concrete Association. Price 50s.

THIS book, making its appearance perhaps a little tardily (the second congress has just been held) is, nevertheless, to be welcomed as a summary of the thought in 1953 on three important facets of prestressed concrete. The first congress reviewed the influence of abnormal temperatures on prestressed concrete construction, the design of statically determinate beams and slabs based on ultimate load and, lastly, statically indeterminate structures in the elastic and plastic states. Little has been added to the first topic since that time so that in this book will be found an excellent résumé of the effect of fire tests on prestressed concrete and also the results of some tests at very low temperatures which show, perhaps surprisingly, that the strength of both reinforced and prestressed concrete is higher under these conditions than at normal temperature. More importantly, in the discussion are recorded the results of some actual fires in Sweden.

With regard to the second topic the intervening years have brought a cessation to the discussion of the relative merits of various formulæ for determining the ultimate load-carrying capacity of prestressed concrete members. Indeed, several of the contributors to the discussion protest at the finesse that has been displayed and time has shown that this was the correct attitude to take. This section is, therefore, perhaps only of historical importance.

The third and most important topic of the three has still to be resolved. The discussion recorded here was merely the beginning of an argument which will go on until sufficient experience has been gained in the laboratory and in the field to substantiate or refute the case that is put largely by M. Y. Guyon. This section of the book is probably the most valuable since it does record the impact of prestressing on continuous structures in a variety of ways.

This book, produced in full in three languages—English, French and German—and thus a welcome departure from the Continental habit of full texts in one language and summaries in others, does, however, suffer from one defect—the original papers are not included. To anyone, therefore, who has no original papers it must be often tantalising to be referred to a paper which has never been published. However, it is fortunate that the Cement and Concrete Association has been prevailed upon to undertake even one part of the work by providing this excellently produced book.

Oils for Heat Treatment. By The Shell Petroleum Company, Ltd. London: Shell Mex House, Strand, W.C.2.—The book presents an account of the use of oils for heat treatment and includes a brief outline of the metallurgy of quenching and tempering. There are two chapters dealing with the hardening of steels, the first discusses rapid cooling or quenching, grain size, critical cooling rates and hardenability, while the second includes time, temperature transformation curves for several alloy steels, together with electron micrographs of steels after being tempered. In the next chapter the question of quenching media and how they act is examined, including the temperature and agitation of the quenching liquid. The constitution, characteristics and quenching performance of the quenching oils, which fall into two main groups, namely, fatty oils and mineral base oils, are reviewed and followed by illustrations and descriptions of oil quenching equipment. Attention is directed to the thermal and metallurgical methods of evaluating the quenching power of oils and certain centre cooling curves included. Points with regard to the tempering of steel of various kinds are set out, followed by some general notes upon the properties required in tempering oils, equipment and the application of oil tempering. Laboratory tests for determining the significant properties of heat treatment oils are outlined and appendices include a glossary of heat treatment terms and definitions, together with a viscosity conversion table.

The Gas Turbine Manual. By R. J. Welsh and Geoffrey Waller. London : Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 30s.—The Foreword to this book points out that since the publication of the first edition, reviewed by us on October 19, 1951, the achievements of the gas turbine include millions of miles of rail traction and a wide range of industrial applications. It also mentions that commercial aircraft fly thousands of hours between turbine overhauls, although no further reference is made to aircraft propulsion in the volume. A wealth of detail describing plant and installations, both British and foreign, has now been added to the book. The authors are at all times practical in their approach, and little space is devoted to recent researches or to projected developments. The adequacy of the treatment of existing engines is evidenced by a name index longer than the subject index : the word " Comprex " does not appear, but " Laffly " refers us to a short paragraph on the projected 10-ton truck.

Merchant Ships : World Built. 1955 volume. By Adlard Coles, Ltd., 7, Brunswick Place, Southampton. Price 25s.—This volume records particulars of new ships of 1000 tons gross and upwards built in 1954 in all the major shipbuilding countries of the world. In all, the book is divided into twenty-one sections, beginning with a tabular summary of ships launched and an alphabetical list of world shipowners and the ships built for them during the year. This is followed by sections, referred to particular countries, in which the ships built by individual yards are listed and which contain photographs and plans of selected ships representative of the various classes of ships built. The final section is an alphabetical register of ships completed during 1954 and includes particulars such as flag, type, owner, shipbuilder, tonnage, deadweight, dimensions and machinery details.

Organic Reagents for Metals and other Reagent Monographs. Volume I. Fifth Edition. By the Laboratory Staff of Hopkin and Williams, Ltd. Hopkin and Williams, Ltd., Chadwell Heath, Essex. Price 15s.—This volume consists of twenty-seven monographs, thirteen of which appear for the first time, relating to some of the more important reagents which are dealt with from a practical and critical point of view.

Each monograph is accompanied by a general bibliography. There are, however, included in the book some reagents that are not used for the detection or determination of metals but for acid radicals, certain organic functional groups, the Karl Fischer Reagent for the determination of water.

Surface Water Yearbook of Great Britain, 1945–53. H.M. Stationery Office. Price 35s.—Much information of value to those concerned with the flow of water in rivers and streams is contained in this latest issue of the surface water yearbook, prepared by the surface water survey branch of the Ministry of Housing and Local Government. The book is a successor to that covering the years 1937–45, which was published in 1952, and contains statistical records of the flows of a number of British rivers, together with their related rainfalls, compiled from measurements made by gauging stations on these rivers. The previous edition contained the records of fifty-two such stations; this new issue includes records of most of those stations for a further eight years, as well as the records of a number of new ones, bringing the total of reported stations up to eighty-one. An edition covering the one-year period 1953–54, which is being prepared, will show a further increase in the number of gauging stations. The present volume closely follows its predecessor in the form of presentation of the monthly flow data. Daily discharges and tables of frequencies have not been included.

Worked Examples in Engineering Thermodynamics. H. J. Smith and J. W. Harris. London : Macdonald and Co., 16, Maddox Street, W.1. Price 35s.—The questions handled in this volume are selected from University of London, Institution of Mechanical Engineers, Brighton Technical College, and other examination papers, to assist students preparing for the B.Sc. (Eng.) degree, Associate Membership and Higher National Diploma and Certificate examinations. Under twenty headings, a set of questions is followed by a set of answers such as would be expected in the time allowed for the questions : divisions range from nine questions on Rotary and Turbo-Compressors to twenty-five on Performance of Internal Combustion Engines. Since theory other than that specifically demanded by the question is not given, the authors recommend students not attending lectures to use a standard text book in addition. A brief index refers to the pages carrying answers so that some back reference is inevitable.

Builders' Materials. Third edition. By B. H. Knight and R. G. Knight. London : Edward Arnold (Publishers), Ltd., 41, Maddox Street, W.1. Price 30s.—In its third edition, this book has been largely rewritten, with the aim of presenting the results of modern scientific work in a selective manner. Six new chapters have been added dealing with (*a*) wall, floor, roof and ceiling linings ; (*b*) iron, steel and steel alloys ; (*c*) non-ferrous metals ; (*d*) asphalts, plastics, adhesives and glass ; (*e*) decorative materials ; (*f*) comfort criteria. There is also an appendix on by-laws, weights of materials, codes of practice, and British standards.

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University College Calendar, 1955–56. London : University College, Gower Street, W.C.1. Price 7s. 6d.

High Vacuum Technique. Third edition. By J. Yarwood. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 25s.

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Experimental Mechanics and Properties of Materials. Second edition. By Carl H. Muhlenbruch. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 21s.

Conduction Heat Transfer. By P. J. Schneider. U.S.A. : Adison-Wesley Publishing Company, Inc., Cambridge 42, Massachusetts. Price 12 dollars 50 cents.

Fuel, Solid, Liquid and Gaseous. Fifth edition. By J. S. S. Brame and J. G. King. London : Edward Arnold (Publishers), Ltd., 41, Maddox Street, W.1. Price 50s.

Value of the Notch Test

At a meeting of the Institution of Mechanical Engineers, last Friday, October 28th, the paper summarised below was read and discussed :—

THE VALUE OF THE NOTCH TENSILE TEST

By Professor J. F. Baker, O.B.E., Sc.D.,* and C. F. Tipper, Sc.D.*

A history of the development at Cambridge of a notch tensile test for the investigation of brittleness in structural mild steel is described. The test procedure and the methods of assessing the temperature limit at which the material becomes brittle are outlined in Part I. Investigations of material from an oil storage tank and from ships which fractured in service show that this notch tensile test gives good correlation with these casualties whatever the nominal stress in the plates at the time of the fracture. The results of Charpy V-notch and Izod tests are given for comparison, and it is shown that the energy absorption criterion used in these tests may be misleading (Part II). In Part III experiments are described in which the tensile test has been used to predict performance in test pieces of more complicated geometric form. Criticisms of the notch tensile test are dealt with in Part IV. In the conclusions, attention is drawn to the fact that the designer of orthodox fabricated structures must be provided with material which is ductile at all operating temperatures and at all stress levels.

Discussion

Sir John Carrol, K.B.E. (Deputy Controller, Research and Development, Admiralty) : We are all impressed by the importance of investigations into brittle fracture and the need to reduce the risk of serious and more dramatically catastrophic failures of modern structures. Design can, of course, play its part in this, but it is a very limited part, and anyone who has had any direct acquaintance with the dramatic difference between detailed stress distribution in a structure and the smoothed out, very much more even, stresses in the designer's calculations cannot fail to realise that it is quite impossible to design against this kind of failure. We are therefore forced back on providing reliable or satisfactory material. That, in turn, implies the devising of suitable or satisfactory tests. The authors are striking directly at the heart of a practical solution of this problem of brittle fracture and the mitigation of its consequences. It is worth suggesting what are the outstanding criteria of a satisfactory test. They are two-fold. One—and this is the absolute *sine qua non*—is that it must give to a very high degree reliable prediction of the performance in service of the material tested. The second, also extremely important, is that it should be capable of being carried out reliably in ordinary working practice. I suppose I should construe your request to me to start the ball rolling as an invitation to express an opinion on the extent to which the notch tensile test satisfies these criteria. Does it appear to be a satisfactory test ? I will give my answer concisely and briefly : yes.

Mr. A. H. Goodger (The National Boiler and General Insurance Company, Manchester) : The paper is very useful indeed. It outlines the requirements of the Tipper test, which is a desirable thing. I find only one thing missing : it does not give the exact amount of crystallinity or fibrous structure which is to be the criterion of goodness or badness. There is very little criticism I can aim at the test which Dr. Tipper devised, because it fits the casualty results almost exactly. In fact, if I make any criticism at all I would suggest that it fits them too well and is rather tailor-made. It looks as though they have experimented with a test which gives the results they have found in casualties. Variations in the test might alter the results. For example, the paper says that rate of loading or straining does not affect the results. Is that a true statement or would you get varying results if you varied the rate of loading from very slow up to an explosive rate ? Moreover, it is scarcely correct to say, as the paper says, that once a fracture has changed to a 45 deg. shear fracture it is unlikely to change back or propagate in a brittle manner. The authors are fair in correlating the various tests one with another because in the investigations which we did on the Fawley tank we obtained results at variance with those of the authors on the impact tests and, in fact, most of the tests we did on the plates other than the initial plate which started the fracture would have given results considerably lower than those given in Table I of the paper. In fact, they would have weeded out the plates as being rejected under the then known criteria of brittle fracture needs.

I have this week finished an investigation on some casualties in which I have used the variety of all the tests—the Tipper test, the Charpy V-notch test, the Izod test, the van der Veen test ; and there was a considerable degree of correlation in the results, both in the mechanical figures and in the crystallinity fracture results. If the Tipper tests explained everything, and the statements in the paper represented all there was to say on the matter —and were the only tests to be used—the logical thing would be to scrap the greater part of all the constructions in existence made in B.S. 13 steel. That would be a very expensive method, but in those circumstances it would be the only safe thing to do because most B.S. 13 steel would be in a brittle condition ! There seem to be very satisfying indications that more and more attention is being directed to initiation and associated factors rather than to repeated tests of notch brittleness—notably the rate of loading, straining or rate of change of loading. Probably the correct view is that B.S. 13 steel will behave as satisfactory ductile steel until it is made to behave otherwise. In other words, it is the initiation of the brittle fracture which seems a very important part of the study, and few ordinary tests give any guidance there.

One of the difficulties with notch brittle testing is to know which criterion to use. The 50 per cent crystallinity criterion does not seem to fit everywhere. The criteria are arbitrary—50 per cent crystallinity, 15ft-lb or 20ft-lb—and are made to fit certain cases. They are not fundamental and certainly do not seem to fit all cases. It seems as though in the absence of further evidence on initiation, 100 per cent fibrous is the only safe standard, judging from the latest casualties which I have examined. This seems to indicate that before more is known about initiation and, in particular, rate of loading, it is rather too early to standardise any acceptance test for plate material, even the Tipper test, excellent though it is.

Dr. A. A. Wells (British Welding Research Association, Abington, Cambridge) : In the controversy which has raged for a decade on the subject of transition temperature tests for structural steels, the work of Professor Baker and Dr. Tipper has stood like a rock, where many other investigators with their tests have emerged full of promise only to founder on account of lack of correlation with casualty experience. If a specimen shows ductile fracture in the Tipper test, at

* Engineering Department, Cambridge University.

the lowest service temperature of a structure, most people have come to regard the possibility of brittle fracture in that structure as a risk which may be dismissed. In other words, in comparative terms the Tipper test is a conservative test. In absolute terms, however, the conservatism is not extreme. An observer unfamiliar with the situation, bearing in mind that a structure could be destroyed by brittle fracture at any temperature below its transition temperature, would call for a margin of safety of 100 deg. Cent. or more between his lowest service temperature and the brittle transition temperature. Under such conditions he could afford to ignore all the details of test correlation and still be certain that there was as big a margin of safety on brittle fracture as there was on ductile collapse from overload. Unfortunately, the best and most expensive steels now in existence would hardly yield this transition temperature margin for normal structures, let alone the structural mild steels. So arises the temptation to use transition temperature tests which are less conservative than the Tipper test. I think we must accept that the Tipper test is a very conservative test from the point of view of being very trustworthy and is one which will come into the future rather than the present. One therefore cannot assess notch brittleness in terms of any one test. For the time being, in order to distinguish many different steels in the classes now being used, one has to turn either to another test or to another interpretation of the same test. I should like to have the authors' reactions to the consideration of the criterion of so much plastic contraction at the centre of the specimen as an alternative to the amount of crystallinity.

Mr. G. M. Boyd (Lloyd's Register of Shipping) : As Professor Baker said in his opening remarks, the suitability of a steel is in the long run proved only by its service behaviour, and therefore any test, to be suitable, must correlate satisfactorily with service experience. The investigations on material from structures fractured in service have indicated that the best correlation with service performance is obtained when fracture appearance is used as the criterion. This criterion also appears to be the least sensitive to specimen geometry or to rate of loading. The most suitable test, therefore, should be one which is large enough to display the character of fracture clearly. This immediately gives an advantage to the notched tensile test, and some others, over the small impact tests. The test described in the paper is essentially a fracture appearance test, and, as shown by the diagrams, it affords a reliable index to service behaviour. Incidentally, we have other evidence besides that given in the paper. This is not to say, however, that this is the only form of test which does so. There is considerable evidence to show that some of the other fracture appearance tests may also do so. It is often said that the fracture appearance cannot be measured and that its assessment is strongly influenced by personal error. It has been found in practice, however, that these misgivings are exaggerated and that it is feasible to apply the criterion without ambiguity. In general it is found, in most notched tests, that the fractures are either predominantly fibrous or predominantly crystalline, with relatively few border line cases, even in the transition zone. It is therefore practical to establish the temperature at which the character of fracture changes. There is no ambiguity whatever about distinguishing between fibrous and crystalline areas in a fracture, and any doubts on estimation can be resolved by actual measurement. That can even be done by unskilled people once it has been pointed out to them and doubts on the matter of estimation or the crystallinity can be resolved by measurements. One of the main practical drawbacks to the notched tensile test is that in order to attain a reasonable breadth-to-thickness ratio with thick plates, within the capacity of the usual run of tensile testing machines, it is necessary to reduce the original thickness by machining. This machining need not be very accurate and it is probably no more difficult or costly than that required for an equivalent number of Charpy specimens. There are, however, other fracture appearance tests which can be made in full thickness up to about 1½in without extra machining, and it may be that such tests would be preferable for the greater thicknesses.

Dr. N. P. Allen (Metallurgy Division, National Physical Laboratory) : This is a highly controversial subject and we should therefore, begin, I think, by drawing attention to what I consider is the most valuable feature of the paper, and that is the addition which it makes to the collection of information which all goes to show that when the brittle fractures occur in mild steel structures it is because the steels are being used at temperatures below their transition temperatures; and therefore the transition temperatures of the steels ought to be lowered to the greatest degree found economically practicable. This paper added to the conclusions which had been formed but the accumulating information is increasingly valuable.

Where the authors go further and claim that they have a uniquely satisfactory test which correlates with service behaviour, they are perhaps on a little more dangerous and difficult ground. I feel that perhaps they have been a little less than completely fair to the conventional Charpy " V "-notch test and, with Mr. Goodger, I have been a little concerned about the differences in the test results on the collapsed oil storage tank. That material has been tested in one or two places and we have found rather significant differences between the impact test results recorded in Table I of this paper and others which have been given. It is true that if we take the lowest impact values which have been observed, we could say that all these materials were liable to brittle fracture, as shown by the Charpy impact test. It is not for me to say that either of the sets of observations is wrong or to choose between them, but there is a discrepancy, and if we take note of it a great deal of the evidence against the Charpy impact test in that table vanishes. In Table II of this paper we have only to reject two of the Izod impact results as being possibly faulty to have a conclusion which agrees entirely with the American conclusion that steels which at service temperature have " V "-notch impact values below about 15ft-lb tend to be dangerous. I do not myself see why one form of notch test should be very much superior to another and I therefore think that the smaller type of test, of which the steel industry has so much more experience, may in the end prove to have sufficient value to justify its continued existence.

I want, next, to ask whether it is reasonable to expect that any one test should be able to correlate with the results of service. This brittle fracture phenomenon is complicated ; there are factors relating to the quality of the steel and factors relating to the structure and the way in which the structure is used. Consequently, we would not expect the results of one test to correlate with the conditions for failure in other types of structure. That is not a reasonable expectation. Consequently, we naturally take suggestions of this kind with a little caution. By way of establishing the point, the rate of loading is certainly of extreme importance. I have this afternoon had in my hand two pieces of mild steel chain. This chain had been tested twice, once under static loading and once with impact tensile load under the same conditions. The one loaded statically had stretched enormously but to all appearances there was nothing wrong with it, but that which had been subjected to impact load had snapped without any sign of elongation. The conditions under which the material had been stretched had made a great deal of difference to the onset of brittle fracture. I have in mind that the amount of stored energy in the structure must have a great effect on the question of whether the fracture is tough or brittle. An ordinary gas cylinder is always tested, when tested to destruction, with internal pressure of water, and in those circumstances it usually opens quite quietly with an ordinary tearing rupture. It is almost unknown for it to shatter entirely. Nevertheless, when a gas cylinder fails in service, when filled with compressed gas and, therefore, there is very much more stored energy in the cylinder, it often shatters. Failure can result in explosions in a fair number of the cases. I think the amount of stored energy in the structure affects the follow-through which decides whether the failure shall be brittle or ductile. I feel that the quality of the steel with respect to the tendency to brittle fracture is moderately satisfactorily summed up in the transition temperature, as measured by a variety of tests, but we do not know enough of the characteristics of the structure which lead to the tendency to brittle fracture. A job remains to be done in that direction before we can define the quality of the steel necessary for a given type of structure.

Mr. T. S. Robertson, (Naval Construction Research Establishment, Dunfermline) : I feel that this paper will be welcomed by all interested in the brittle fracture problem because it introduces a test with features which remove some of the complexities of notched bending tests. A suitably wide specimen stresses and strains a considerable portion of the material uniformly and the appearance of the fracture provides an assessment of brittleness. The transition temperature band width is thus much reduced, though a certain degree of scatter is still evident. It is usually possible to make an assessment within plus or minus 5 deg. Cent. to judge the probability of fracture at some temperature in an ambient range covering 35 deg. Cent., as shown in Table II of the paper. This table shows how narrow is the range over which we experience these fractures. The adoption of full plate thickness as essential recommends the test to all who have examined macro-segregation in steel plates, so that the suggested thinning down of the generally more brittle thick plates seems to be a retrograde step. The possible adoption of heat-treated steels for highly stressed structural members in thicknesses which may present problems in uniformity of process gives point to the necessity for a full thickness test. In the paper the comparison of notch tensile with Izod and Charpy energy values substantiates the conclusions of Pellini that the use of Charpy energy as an acceptance criterion requires some other test which will determine where to assess each class of steel on the Charpy curve. With regard to the authors' assessments of Charpy crystallinity, it is felt that a statement of the degree of danger in terms of a

given brittleness would be more appropriate than assessment of appearance measured at the temperature of casualty.

Mr. Peter P. Benham (Imperial College of Science and Technology): In considering brittle fracture problems as a whole there are various aspects which affect the transition temperature, and one which has received very little consideration is that of prior cyclic loading. I am thinking of certain structures which undergo some cyclic loading—ships, bridges, oil storage tanks, &c. Although this cannot be thought of in such terms as fatigue application, there will be a certain number of cyclic loads. Will this have some effect on the transition temperature? Will it move the transition temperature and bring us into a range which will no longer be safe for the material? There is not much information on this aspect and we thought that a few exploratory tests might be worth while to see whether a fuller research programme was justified. We have given the test pieces ten prior cycles of load, in this case up to about 4 per cent strain, the cycles being from zero load to maximum tension and back to zero again. We have found that there is considerable change in the transition temperature, reducing it by a matter of 10 per cent. The range has been spread, although there is not a great deal of change in the percentage reductions. I feel that perhaps the notch tensile test can be useful for investigating this aspect of transition temperature.

The next point I should like to bring out is on the question of fracture appearance. Dr. Tipper has the usual type of fracture appearance shown in the plates reproduced in the paper. We also experienced fractures of this nature. We also had fractures of multi-plane shear types. For no apparent reason they were mixed with the other type of fracture, well above the transition temperature. Of course, below the transition temperature we had the normal crystalline type of fracture and a slight combination of both. This is interesting and I wonder whether Dr. Tipper can give any idea of what happens here.

Mr. W. C. Holliday (Whessoe, Ltd., Darlington): The authors have emphasised, as have others to-night, that this is essentially a fracture appearance test and it seems to me that the important thing is to establish the type of fracture which would be regarded as acceptable for selecting steels for structures which have to work at low temperatures. Engineers and fabricators have for some time asked the steelmakers to produce steel which would have 100 per cent fibrous fracture when tested at the service temperature. So far this simple specification has not been met and it may well be that the test which they are using does not give them the type of information we should like. These are primarily impact tests and the fractured impact specimens have normally failed fully or partially by cleavage. In spite of the drawback, we are using improved steels. These have been developed to give better notch ductility properties at low temperature service conditions and they are generally known as ND1, ND2 and ND4. They differ in so far as their specifications require an average Charpy V-notch impact value of 20ft-lb at temperatures of 0 deg. minus 15 deg. Cent. and down to minus 50 deg. Cent. respectively. It would be interesting to learn whether the authors have examined these steels and, if so, what type of fracture they obtained for notch tensile specimens tested at the temperatures for which a minimum average Charpy V-notch impact value of 20ft-lb is specified. There is another important part of welded structures which does not appear to have received the attention which it should—the weld metal. It may well be that this part of the problem has been avoided because it is probably much more complex than the problem which has primarily been discussed to-night. We cannot ignore it, however, since most of the failures which have occurred have invariably been associated with a weld defect. The difficulties are many, but they are made greater still because the impact test used to-day gives wider scatter than we normally get with parent plate. For example, the impact value varies considerably for the thickness of the weld.

Mr. G. Burns (D.A.E.R. Department, Admiralty): Several previous speakers have raised the question of whether the test is rather too severe in deciding at what temperature material is unusable, and I should like to pursue that point a little further in connection with Table II of the paper. Some twenty samples are listed there and eight of them would have been rejected as unsuitable for use at temperatures considerably above those at which presumably they had served for some time. Three at any rate are listed as being fairly substantially pitted, and I should have thought that suggested a fair time of service. Samples Ha and AVR have transition temperatures of 55 deg. and 50 deg. Cent. respectively, and both are marked as substantially pitted. I think that indicates a fair length of service. Yet they did not become origins of failure until the temperatures were down to 20 deg. or 10 deg. Cent. That suggests that perhaps they need not be thrown out if the temperature has never fallen below 30 deg. Cent.

Dr. S. A. Main (Hadfields, Ltd.): In his opening remarks Professor Baker mentioned that the Cambridge conference was instituted in 1945 because by then the problem had been isolated and it was thought that the trouble was with the steel. I think he said the steel was "suspected." At that conference, to the best of my ability I contested that attitude, not, I am afraid, with much help from my colleagues from the steel industry. As I mentioned there, it seemed to me that the evidence produced at that time showed very strongly that much more could be done by attention to the engineering aspects than by attention to the metallurgical aspects—that is to say, the quality of the steel. I am therefore glad to learn from the paper that such attention has produced a lower number of casualties. I feel that much more could be done in that direction. All this shows my attitude towards the present work taking place about steel. The Cambridge conference rightly decided that a study of the metallurgical aspects could also be profitable and the work of the authors and others has abundantly proved the wisdom of that decision. It is evident that suitable care to ensure the use of steel with as low a transition temperature as possible can much reduce the risks. The devising of a suitable test to ensure such quality has been difficult and the present work of the authors, on which they are to be congratulated, has brought it to the brink of success. At any rate, it is much nearer than the work of many others. The authors' success, to my mind, results largely from simplification of their test compared with the notch impact bending test. The notch bending test lumps together, besides the formation of the crack, the effects of its subsequent progress through the material. This, as the authors point out, can only fortuitously correspond with a particular case in service. The notch tensile test gets nearer in this respect, but I still feel that it does not go quite far enough. I do not think the problem will be fully solved until some test is evolved to determine the propensity of the steel to the initiation of a brittle form of crack. I emphasise initiation because once a crack has started in service who can say that things are any longer safe? A notch is itself an arbitrary means of producing a crack and does not necessarily reproduce the service conditions in all cases. Is it not therefore possible to find other means? I think it should not be impossible, following the study of the fundamentals of the formation of brittle cracks.

Mr. R. B. Heywood (Camberley): I should like to ask the authors whether a circular specimen with a notch test in the centre would serve a useful purpose. That would eliminate the geometry effects of width and thickness. It would eliminate the surface effect and one would tend to get more nearly a triaxial state of stress.

Dr. Tipper replied shortly and the meeting closed.

Electrical Power Development in the U.S.S.R.

THE Kuibyshev hydro-electric power station on the Volga River, and its associated high-tension transmission line to Moscow, are both nearing completion, according to a recent report in *Soviet News*. The Kuibyshev power station was briefly described in THE ENGINEER of March 18th last; it is a very large development, with an ultimate installed capacity of 2100MW and an estimated power output of 10,000 million kWh annually. More than half of its output is to be transmitted to Moscow, the remainder being consumed in the Urals and Volga regions. In the report mentioned above D. Achkasov, the administrative head of the Russian Ministry for the Construction of Power Stations, is quoted as saying that such large quantities of power have not before been transmitted over such large distances in the Soviet Union. The transmission line from Kuibyshev to Moscow is to be 900km in length and will operate at 400kV. It will have three separate circuits, Mr. Achkasov said, consisting of steel-aluminium conductors each with a diameter of 30·2mm; there will be nine conductors, not counting the earth wires. At the Moscow end of the line 220/110kV transformers are being installed to connect with the Moscow grid, and also air break switches using compressed air at 40 atmospheres. The line is to be controlled from one centre, Mr. Achkasov noted. It is also noted in the same publication that there are about 100 hydro-electric stations of average and high-capacity operating in the Soviet Union at the present time. Several dozen more are under construction, with a capacity almost treble the figure for those operating last January; it is expected that the country's hydro-electric capacity will have increased by 25 per cent as a result of works completed this year.

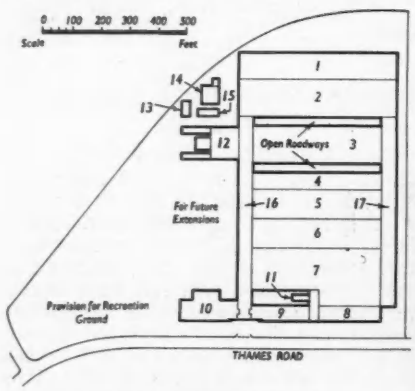
HYDRAULIC FLUID.—Shell-Mex and B.P., Ltd., has introduced a new hydraulic fluid which is claimed to combine fire-resistant properties with good hydraulic characteristics. The hydraulic fluid has been subjected to exhaustive tests and it is stated that when a fine spray of the fluid is directed at the flame of an oxy-acetylene torch it either fails to ignite or, if ignition occurs, the flame dies immediately the torch is extinguished. The fluid rolls off in globules or volatilises without firing when dropped on to a steel pipe heated to 1200 deg. Fah. Other tests on the fluid are stated to have shown that its load-carrying properties are equivalent to those of typical mineral hydraulic oils of similar viscosities, and that it has no adverse effect on metals commonly used in pump construction, even at high temperatures.

Sheet Metal and Plate Fabrication Works

Frederick Braby and Co., Ltd., has recently opened a new factory, at Crayford, Kent, to take the place of the company's London plants at Euston Road and Deptford, which could not be extended to satisfy the need for increased production. The new factory occupies a 28½-acre site with good rail and road access and is fully tooled to produce sheet metal goods, pressings, pressure vessels, light structural steelwork and mechanical handling equipment.

SINCE the war trade expansion has caused an increasing condition of congestion at the Euston Road and Deptford factories of Frederick Braby and Co., Ltd.. The existing factory space was limited and since the solution of the problem by means of large rebuilding schemes was not possible, as they could not be embodied in the London Plan, the company decided to move to another location. A site of 28½ acres at Crayford was selected, which has a ballast subsoil having good load-carrying properties and good drainage, and also good access by both road and rail.

Our photograph gives an aerial view of the new London works at Thames Road, Crayford, Kent, which at present cover nearly 12 acres, with plenty of space being available for future expansion. The plan of the plant is shown in our line drawing and the shops, which run north to south, are constructed on the north light principle and all the 3000 tons of structural steelwork has been fabricated in the Glasgow works of the company. Reinforced concrete ground beams carry the external walls and there is a brick surround some 8ft high at the shops, which have double skin asbestos roofing and floors of reinforced concrete having large areas laid with rolled asphalt or a surface suitable to a particular trade. The shops are generally 450ft long, except the structural steelwork and fabricated platework departments, which are 550ft in length, and the stores and despatch departments, which each have a length of 650ft.



1—Structural steelwork department.
2—Fabricated platework department.
3—Galvanising department.
4—Wire lattice department.
5—Tank, cistern and cylinder department.
6—Perforating department and tool room.
7—Sheet metal department.
8—Covered cycle and car park.
9—Administrative office.
10—Canteen and welfare.
11—Clinic.
12—Boiler-house and services.
13—Building maintenance department.
14—Garage.
15—Acid neutralising unit.
16—Stores and receiving department.
17—Despatch department.

Plan of London works, Crayford

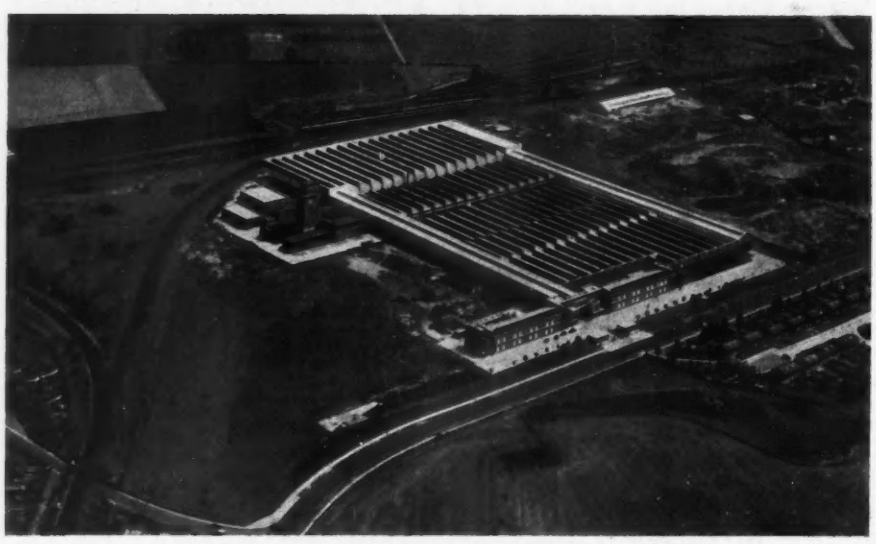
Boiler-house, showing the four "La Mont" oil-fired boilers for space heating

Reinforced concrete has been used for the water tower and the administration buildings, which have Fletton sand-faced brickwork on the reinforced concrete frame and concrete floors finished with Rhodesian teak laid on mastic. Terrazzo has been used for the halls and stairways and the ceilings are of hung pattern, having an air space for insulation purposes and to take hot water heating coils embedded in special plaster. In the conference room the ceiling and frieze are of acoustic plaster and the walls are covered in hardboard while, in order to reduce the effect of noise in the mechanical accounting department, there is a surround of acoustic tiles and double glazing to the corridor. All the corridor partitions and office divisions are formed of Braby's "Bar-Form" partitioning in aluminium alloy having a semi-polished anodised finish and single glazing. A canteen to seat 600 in the main hall and a further 125 in various staff rooms is provided, together with a well-equipped kitchen having separate food preparation rooms. The floor is of Rhodesian teak in the canteen and quarry tiles in the kitchen. The main buildings are faced with multi-coloured bricks and Portland stone, and the mansard roof has been sheathed in copper by the company's metal roofing department.

At the entrance to the works are a number of drying rooms for the convenience of the personnel, which numbers about 900. These rooms are fitted with heated rails and hangers to take wet clothes, have anti-condensation "Pyroc" sprayed on the ceilings and there are, in addition, tubular heaters for drying purposes when the boiler plant is not in use. For general medical treatment and for dealing with accidents there is a medical block consisting of a surgery, consulting, examination, and light treatment rooms and two rest rooms.

The electrical power is supplied by the London Electricity Board and comes in at 11,000V to a substation and there are three 500kVA transformers with a capacitor connected to each to maintain 0·98 lagging power factor. Current at 415V a.c. is fed into aluminium overhead main busbars, carrying 1000A, while spur busbars, carrying 400A, take the current across the shops to the machines. Throughout the shops the lighting is blended consisting of sodium and tungsten lamps in one fitting and giving between 8 to 10 lumens per square foot at working level.

Heating of the whole of the factory and offices is effected by a low-pressure high-temperature hot water system, supplied by four La Mont water-tube boilers, each of 9·5 million B.Th.U. capacity. The boilers, illustrated above, are oil fired, using oil of 900 seconds Redwood, and equipped with Todd variable-control burners. For the storage of the fuel there are three 29,900-



Aerial view of the London works of Frederick Braby and Co., Ltd., at Thames Road, Crayford

gallon tanks. A pressure of 44 lb per square inch is maintained and the plant is designed for a flow at 256 deg. Fah. and a return at 200 deg. Fah., the flow temperature being attained by means of a 2000-gallon supply tank placed at the 100ft level in the water tower and so giving the necessary head. Four "Mopumps," two of 33,000 and two of 46,200 gallons per hour capacity, circulate the water to the "Copperad" unit heaters which heat the factory and are controlled by local thermostats. Some of the units are connected by ducts to the outside air, so that fresh air can be circulated in the shops when required. As already mentioned, the administrative buildings are heated by low-temperature ceiling panels and convector heaters and are zoned on a separate control. Within the water tower, which is 110ft high and encloses the 6ft diameter brick chimney of the main boilers, there is a 2000-gallon tank for the hot water heating system at the 100ft level, a 45,000-gallon main storage tank at the 80ft level, and 10,000-gallon tank for wash water circulation for the galvanising department at the 40ft level. The base of the tower houses two "Broomwade" compressors, one of 660 and one of 300 cubic feet per minute capacity, which provide compressed air throughout the factory. Both the water tower and the boiler house are supported on "Franki" piles. Ejector pumps have been installed to handle soil and storm water owing to the shallow depth of the sewer in the main road. An interesting point in connection with the construction and equipment of the new factory is that many of the items, such as office partitions, windows, staircases, gutters, water tanks, lockers, and the constructional steelwork, have been produced in the company's own factories.

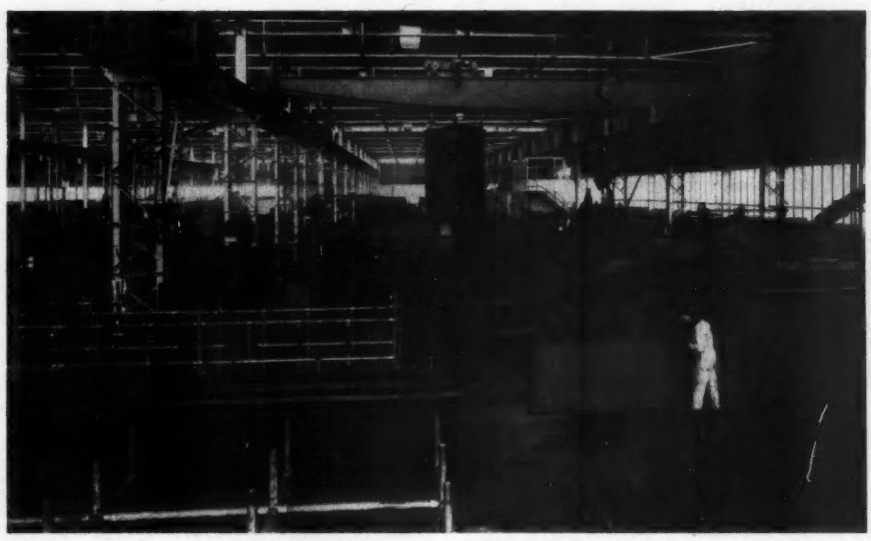
General Description of Plant

The structural steelwork and fabricated platework departments have the normal equipment of punching, drilling, cropping and straightening machines, suitable for all classes of light structural steelwork used for single-storey sheds and farm buildings. Platework up to ¾in thick can be handled, most of which is for industrial purposes, including road tank wagons, pressure vessels, hoppers and chemical plant. For working the plate material there is a 300-ton hydraulic bending and forming press and a number of hydraulic presses for dishing and flanging the circular ends of tanks and pressure vessels up to 6ft diameter by ½in thick. The fabricated plating shop, which is illustrated here, is served by one 15-ton, two 10-ton and one 5-ton cranes, while the engineers and structural departments each have cranes of 5 tons capacity. For welding purposes there are powered turning rolls, tilting tables and manipulators.

The galvanising shop, which has a width of 130ft, is planned on a straightforward flow line consisting of degreasing in a cold solution of "Speiro" emulsion, pickling in a 12 per cent solution of hydrochloric acid, followed by immersion in two water tanks, fitted with agitators, and a dip in a fluxing solution consisting of zinc ammonia chloride, in a concentration of 4 lb per gallon, and a wetting agent. For drying the work pieces there are two conveyor systems. One conveyor passes through a drying oven which is heated to 120 deg. Fah. by waste gases from the galvanising furnace and is fitted with gas bar burners for topping if necessary. The other unit is a floor level drying conveyor, the drying being effected by heat radiated from walls and floor heated by waste gases. After drying the work is dipped in the galvanising baths, of which there are three, two measuring 8ft by 4ft by 7ft. 6in and 4ft 6in deep, respectively, and a third measuring 16ft 6in by 6ft 6in by 6ft 6in deep. The galvanising tank furnaces are coal-fired through screw feed Bigwood stokers and the whole operation is automatically controlled by instruments located in the supervisor's office. The working temperature of the metal ranges from 445 deg. to 465 deg. Cent., according to the work and the flue temperatures range from 650 deg. to 750 deg. Cent. for the small baths and from 750 deg. to 825 deg. Cent. for the large bath.

Special attention has been paid to ventilation and twenty-two extractor fans are placed in the roof, mainly over the baths. In addition to the general heating system unit heaters in the walls

Perforation department showing the wide range of perforating machines installed



The fabricated steelwork department

Part of the large sheet metal department showing some of the equipment

blow fresh warmed air into the shop, and separate washing and drying rooms are provided for the personnel of the department. After galvanising and weighing, items which require testing pass to a bay equipped for that purpose. Testing is by an air-hydro pump and the test water is provided from overhead tanks which are automatically supplied from a 50,000-gallon underground storage tank into which the water, after being used, flows via settling and filter pits.

Associated with the pickling process is the acid neutralising unit which has been installed to satisfy the requirements of the local sewerage authority, that effluent discharged into the sewer should be approximately neutral and contain not more than fifty grains per gallon solid content. The plant consists of a collecting sump from which a rubber lined pump delivers the acid to two 16ft diameter neutralising and storage tanks fitted with agitators. When the pH. meters show that the contents have been neutralised, the liquor content is pumped into sludge filter presses, where the solid matter forms into a cake and the liquid is discharged into a final settlement tank. Thence it flows over a weir, either to the industrial drain or to be pumped to the wash-water storage tank in the tower.

The acetylene requirements of the factory are supplied by two 10 cwt carbide to water generators and the spent carbide residue is collected in an outside pit from which the sludge flows into the neutralising tanks. Oxygen supplies are provided by a liquid oxygen plant, the liquid oxygen being delivered in spherical containers and poured into the evaporator, where it vaporises and fills the storage cylinders. The pressure in the cylinders is 1980 lb per square inch and the oxygen is piped to the factory at 200 lb per square inch.

Wirework is concentrated in the lattice department where hand craftsmen make a variety of screens, panels, baskets and machinery guards. Domestic hot water tanks and cylinders, cold water cisterns and small oil storage tanks are made in the tank department, which is equipped with squeeze riveting machines for the cold closing of annealed rivets, and a 150-ton press for forming cylinder ends. An illustration on page 663 gives a general view of the perforation department, in which is installed a battery of modern perforating machines ranging from a 350-ton press, capable of perforating heavy steel plate up to 15ft long by 5ft wide, down to small fast-running presses for the perforation of sheet lead and plastics. A wide variety of products such as ventilators, trunking, casings, guttering and barrows, &c., are made in the sheet metal shop, of which we reproduce a photograph showing some of the equipment. An adjoining press shop produces a variety of pressings and argon-arc plant for the welding of non- ferrous metal has been installed.

Tools for the various departments are produced in the tool-room, which includes a special section for making the perforating tools. For factory maintenance purposes there is a sawmill, an electrician's shop and engineers' stores, and a garage for overhauling the works transport.

The architects for the new works were Messrs. H. Courtenay Constantine and A. A. Steward, the consulting engineers were Messrs. W. T. Henry and Partners, J. J. Stordy, Stinton Jones and Partners, and Sir Duncan Watson, and the main contractors were G. E. Wallis and Sons, Ltd., and Higgs and Hill, Ltd.

CAST PRECISION DIES AND MOULDS.—The introduction of a new system of producing castings at the works of Darwins, Ltd., Tinsley, Sheffield, 9, is announced by the company. This "Tru-Process" system is an investment technique employing a refractory material which will resist the attack of steels and other alloys of high melting point. It is stated to be a logical development of the familiar "lost wax" process, being much cheaper and quicker while retaining the same degree of accuracy. With it precision castings for dies and moulds used in mass production of glass, plastics, non-ferrous metal and other components can be produced directly and to a high degree of accuracy in finish and size from patterns made in any convenient material, such as wood, brass, aluminium or plaster. Appropriate grades of the castings can be heat-treated and hardened, but in many instances no heat-treatment is required and the dies or moulds can be used as cast and without need for finish machining.

Floodlighting Wembley Stadium

Wembley Stadium is now floodlit by a permanent installation which is the most powerful of its kind in the United Kingdom. It consists of 192 floodlights arranged in eight groups of twenty-four, each 100ft above the ground. The lighting load is 340·4kW and the average illumination of the football pitch is about 20 lumens per square foot on the horizontal plane and 25 lumens per square foot on the vertical plane. The method of "training" and installing the groups of lights to give these results is briefly described here.

THE first permanent installation for floodlighting the arena at Wembley Stadium made a successful public debut on Wednesday, October 26th, for the association football match between London and Frankfurt. This installation, which is the largest in the United Kingdom, is the outcome of extensive trials with alternative systems. The scheme that was adopted as a result of these trials was designed, made and installed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It consists of 192 floodlights mounted 100ft above the ground, in groups of twenty-four on eight towers, the total lighting load being 340·4kW. Average values of illumination in lumens per square foot on the football pitch are about 20, measured on a horizontal plane; 20, measured on a vertical plane facing the goals, and 30, on a vertical plane at right angles to the goals.

A subjective assessment of the floodlighting from the grandstand spectators' viewpoint (Fig. 1) is that the pitch appears evenly illuminated without glare, that the touchlines, linesmen, players and the ball stand out effectively, and that such shadows as are present are not distracting.

To achieve such illumination with minimum glare the installation is made up of a combination of four optical systems: first, sixty narrow beam symmetrical optical systems (*N*, Fig. 2), using 1500W "Osram" projector lamps; secondly, seventy-two medium-angle light distribution systems (*M*), and, thirdly, forty-four wide angle light distribution systems (*W*), using 1500W "Osram" general lighting service lamps in both cases, and fourthly, sixteen wide-angle asymmetrical floodlights, with 2kW "Osram" horizon type line filament lamps, installed on each of the two central towers. The floodlights in the fourth group are trained to give a high level of illumination on players at the far side of the ground and are cut-off sharply to prevent glare in the eyes of the spectators on the terraces opposite. The system is flexible in that the floodlights can be trained to give any distribution of light that may be required for events other than football matches.

In designing this installation the G.E.C. lighting engineers and staff of the lighting section of the company's research laboratories used a scale model of Wembley Stadium built at the laboratories, and many separate calculations were made to decide the correct combination of optical systems. As a result, a "training" plan was produced to provide an accurate diagram for use during the alignment of the floodlights and focusing of the lamps. This training plan is reproduced in Fig. 2. The installation is based on the "groups" system of floodlighting in which a number of floodlights are trained on to a number of predetermined positions throughout the arena. For instance, referring to the diagram, Fig. 2, it can be seen that lamps type *N* from the following towers are trained on to the point *A4* on the arena floor:—*P*, *Q*, *P'* and *Q'*. A similar process applies to all the other points marked on the diagram.

Fig. 1—Spectators' view of a football match played under the new floodlighting installation at Wembley Stadium

A procedure for "training" the lamps by daylight (final adjustments being made at night) was evolved. Briefly the lamps were first prefocused with the aid of specially made templates. Then the arena was measured, and "targets" consisting of small circular white discs were placed in positions which had been predetermined and charted on the "training" plan. A remote photometer, fitted with a shutter to exclude all daylight and mounted on a tripod so that it could be adjusted in any direction, was then placed in the arena (Fig. 3) at a point representing the average projected throwing distance of all the floodlights in the group to be trained.

The photometer in the arena was connected by a long flexible lead to a micro-ammeter on the appropriate tower, to enable the engineer aligning the floodlights to obtain immediate readings for each of the many adjustments required. Each unit was then switched on separately and the photometer was lined up to it.

For training each light and focusing each lamp, walkie-talkie radio was used for com-

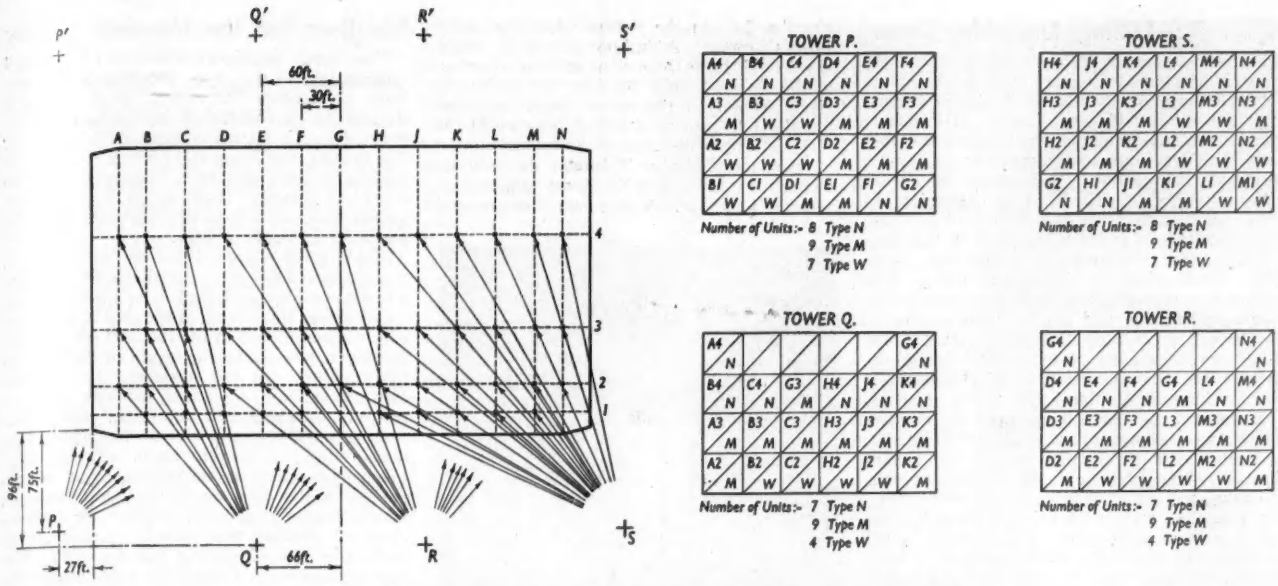

P'
Q'
R'
S'
60ft.
30ft.
A B C D E F G H J K L M N
4
3
2
1
94ft.
75ft.
P
27ft.
Q
66ft.
R
S
TOWER P.
A4 N | B4 N | C4 N | D4 N | E4 N | F4 N
A3 M | B3 W | C3 W | D3 M | E3 M | F3 M
A2 W | B2 W | C2 W | D2 M | E2 M | F2 M
B1 W | C1 W | D1 M | E1 M | F1 N | G2 N
Number of Units:- 8 Type N
9 Type M
7 Type W
TOWER S.
H4 N | J4 N | K4 N | L4 N | M4 N | N4 N
H3 M | J3 M | K3 M | L3 W | M3 W | N3 M
H2 M | J2 M | K2 M | L2 W | M2 W | N2 W
G2 N | H1 N | J1 M | K1 M | L1 W | M1 W
Number of Units:- 8 Type N
9 Type M
7 Type W
TOWER Q.
A4 N | G4 N
B4 N | C4 N | G3 M | H4 N | J4 N | K4 N
A3 M | B3 M | C3 M | H3 M | J3 M | K3 M
A2 M | B2 W | C2 W | H2 W | J2 W | K2 M
Number of Units:- 7 Type N
9 Type M
4 Type W
TOWER R.
G4 N | N4 N
D4 N | E4 N | F4 N | G4 M | L4 N | M4 N
D3 M | E3 M | F3 M | L3 M | M3 M | N3 M
D2 M | E2 W | F2 W | L2 W | M2 W | N2 M
Number of Units:- 7 Type N
9 Type M
4 Type W

Fig. 2—Diagram showing plan for "training" the floodlights at Wembley Stadium

munication between the ground and the towers, and field telephones provided an immediate link with points around the arena. The use of these devices saved considerable time and enabled the work of aligning the floodlights to be completed in less than twelve working hours.

To check the focusing of each lamp, its control was adjusted until a maximum reading was obtained on the micro-ammeter. Then the floodlight was moved in both the vertical and horizontal planes, and aligned accurately with the aid of the micro-ammeter, so that the centre of its main beam was directed towards the photo-cell. Next, a specially made sighting device was attached to the unit and adjusted until its sights were in line with the photo-cell ; thus the sights and the axis of the beam were collimated. The floodlight was then sighted (Fig. 4) on its predetermined "target" and locked in position. This procedure was used for aligning each of the 192 floodlights in the Wembley Stadium installation.

Only a few minor adjustments to the training positions fixed by daylight were necessary when the full-scale night test took place.

Finally, specially designed filament screens were fitted to all the symmetrical floodlights, each carefully adjusted to cut off direct view of the lamp filaments from the spectators, but not the players. It is considered that the accumulation of the direct lamp flux, although small when compared to the total beam lumens, is useful in helping to reduce the diversity factor and in adding to the illumination of the ball when it is travelling through the air.

A characteristic of the floodlighting installation at Wembley is the spectacular effect obtained by the provision of expanded metal resistors in each of the four main feeders, each of which supply two groups of floodlights. Before play begins, and during half-time, the resistors are in series with all the lamps and the effective voltage across the lamps is reduced from 210V to 185V. By the use of contactors and remote control switches, the resistors are shorted out and the illumination is raised to full brightness when the players enter the stadium. This arrangement also has the practical advantage of preheating the lamp filaments and thus improving lamp life.

The welded tubular steel towers on which the floodlights are mounted were built by Tube-wrights, Ltd. They will be accessible from gantries which will extend from tower to tower across the roofs of the stands. Maintenance of the floodlights can be carried out from the rear of each group, and each light has a hinged back to give access easily without disturbing its setting.

Fig. 3—Lining up each floodlighting unit with the help of a remote-indicating photometer mounted on an adjustable tripod

Fig. 4—An optical sight is collimated with the axis of the light beam and is then used to train the beam, in daylight, on the selected target point on the pitch

To ensure adequate weather protection, all the G.E.C. floodlights are of copper and aluminium. Over 5 miles of cable were used for wiring this floodlighting system, and the electrical installation was carried out by A. G. Allen and Co., Ltd., Wembley.

UNIVERSAL MILLING MACHINE.—The Central Tool and Equipment Company, Ltd., Centec Works, Hemel Hempstead, has introduced a new small universal milling machine known as the "Centec 2B." It is an enlarged version of the "Centec 2A" and has a 25in by 5in table with a longitudinal traverse of 13in. The machine is driven by a ¾ h.p. motor through a six-speed gearbox, giving spindle speeds from 85 r.p.m. to 1400 r.p.m. If required a double speed range of 170 r.p.m. to 2800 r.p.m. can be provided for the machine. Ancillary equipment available with the machine includes a vertical milling attachment, offset boring head and rotary tables.

Hydraulic Luffing Dockside Crane

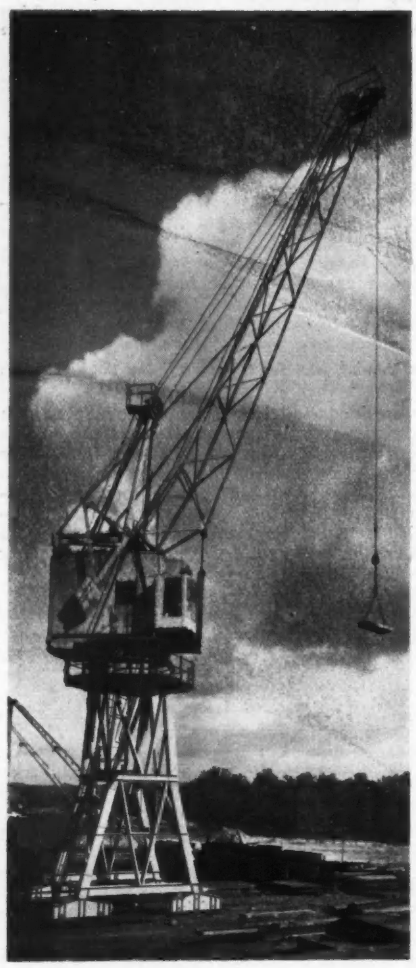
A NEW design of cargo-handling dockside crane, in which the luffing motion is hydraulically actuated, has been developed by Clyde Crane and Booth, Ltd., Rodley, Leeds, and is being made at the works of the firm's associate company, the Clyde Crane and Engineering Company, Mossend, Lanarkshire. This crane, which is being produced initially in four capacities of 3, 5, 7½ and 10 tons, has each of its motions electrically driven by independent motors, and the luffing motion is effected by a hydraulic ram. This introduction of hydraulic luffing has eliminated the use of the shafts associated with mechanical luffing, and allows ample room on the superstructure for the remainder of the machinery, which has been arranged to permit easy access for inspection and maintenance. The makers state that the luffing control is equivalent to that obtained on an electric crane and the use of a relief valve in the hydraulic system provides an effective safety measure, whilst shock is eliminated when stopping the luffing motion. The jib cannot be over-luffed, any over-limit movement being checked by the luffing ram meeting stops in the cylinder. In the hydraulic system the fluid is metered by two pumps, pumping into one end of the cylinder and out of the other; the jib is thus always under control and can only move in relation to the speed of the pump driving motor. When the jib is at rest the fluid is locked in the system by an automatic valve and a solenoid brake on the motor shaft. This arrangement provides a double lock to prevent the pumps being driven in the reverse direction by the weight of the jib, which is held rigidly when not being luffed.

One of the new "Level Hydra-Luff" cranes, as they are called, can be seen in the illustration herewith. The superstructure is carried on a portal carriage, consisting of a branch framework of structural steel which is extended upwards to form a tower carrying the jib foot pin, and to form the mast for the luffing rope system. The machinery house on the superstructure incorporates the driver's cabin, which extends beyond the main walls at the front and has large glazed sections through which there is a clear unobstructed view of the working area. The jib is of tubular construction with a triangular section, and balance weights on supporting levers are connected by ties to a point about midway up the jib.

The crane is mounted on a circular roller path through which it is supported on a ring of taper rollers, and it is fitted with a segmental slewing rack. Slewing is effected by a flange-mounted motor and reduction gearing driving a spur pinion engaging the rack. A disc brake fitted on an extension of the slewing motor shaft is applied by three hydraulic cylinders controlled by a common plunger connected to a pedal in the driver's cabin. A locking device is provided to anchor the slewing portion of the crane when it is at rest.

The hoist motion is driven by a slipring induction motor through single-stage reduction gearing and this drive is fitted with a solenoid brake. The hoist rope passes over a pulley at the top of the mast, and from there is reeved between the mast and the jib head to give the level luffing action. Slewing speeds are obtained through a B.T.H. "Stacreep" system, which gives two steps of slow-speed control when hoisting or lowering with the crane.

The luffing motion is imparted by a hydraulic cylinder assembly which, as can be seen in the illustration, is mounted on the left-hand side of the cabin between the base frame of the crane structure and the apex at the foot of the jib. This cylinder has a ram with a piston head, and the hydraulic system is supplied by two pumps mounted in tandem and driven by a common motor. The direction of the fluid flow through the pumps is reversible and depends upon the direction the motor is running. During the luffing operation oil is pumped into the cylinder at one end and metered out through a pump at the opposite end, the pump capacity being suitably adjusted to allow for the difference in swept volume between one end of the cylinder and the other. It will thus be seen that at all times during a luffing operation the movement of the ram is dependent on the number of revolutions of the pumps. A solenoid-operated valve locks the fluid in the system when the pump motor is stopped. A dashpot is fitted to retard the solenoid valve to prevent sudden stopping, and the jib is actually brought to rest by the solenoid brake on the motor shaft. A relief valve fitted to prevent excessive pressure in the hydraulic system operates if the luffing motion is reversed too suddenly. This valve also provides an effective safety device when the ram reaches the end of its stroke. A tank maintains the head



Electrically-driven dockside crane with hydraulic luffing

of fluid in the hydraulic system and oil filters ensure a supply of clean oil to the pumps.

When the crane is not in use the jib is "luffed in" to minimum radius where it is automatically engaged by a stowing hook. This hook is partly balanced and is disengaged by a pull wire from the driver's cabin.

Limit switches for a compensating overwinding gear are fitted to both the hoisting and luffing motions. Compensation is effected through a differential unit driven through gears from the hoisting and the luffing motions, and it enables full advantage to be taken of the extra height of lift available when the jib is working at short radii. This compensating gear biases the hoist limit switch to suit the position of the jib, and through it the hoist motion is stopped when the hook reaches a predetermined distance from the jib head irrespective of the radius of the jib. Further hoisting is then prevented until the jib has been luffed in, and luffing out is prevented till the hook is lowered. This unit also acts as a normal limit switch at the limits of travel of the luffing motion.

In the driver's cabin the two master controllers covering hoisting and slewing motions are interconnected by a joystick, fore and aft movement of the stick controlling hoisting and right and left movement controlling slewing. Luffing is controlled by a lever working in the fore and aft direction. The travelling motion for positioning the crane is operated through a drum controller.

Steriliser for the Canning Industry

THE food machinery division of Mitchell Engineering, Ltd., has developed a new form of steriliser for canned foods, which is claimed to be capable of considerably greater outputs than standard equipment used hitherto. The heating, sterilising and cooling cycles of the equipment have also been designed to give an improved process, resulting in a very high-quality pack of the more delicate kinds of canned goods such as peas or fruit.

The Mitchell-Webster "Hydron," as it is known, consists essentially of a central chamber forming a steam compartment, flanked by a water column on each side, and having at the base a water seal which is maintained at the required level against the steam pressure by the height of the water in the columns. In the sequence of operations cans are fed from a seaming machine at a temperature of about 170 deg. Fah. into a preheating section of the "Hydron," where their temperature is raised to about 185 deg. Fah. From this section the continuous chain of cans passes into the water seal of the ingoing column, and as they move down this column the temperature and pressure progressively increase to the maximum required—about 240 deg. Fah. The cans then pass up through the water seal at the base of the machine into the steam compartment without encountering sudden changes in temperatures or pressures. During their passage round the steam compartment the cans are held at the required temperature for a specified period before they pass down into the water seal, where their direction of travel is again changed, and they are conveyed up the outgoing water column.

After the partially cooled cans break surface at the top of the outlet water seal a short period of air cooling follows to make sure that the pressure reduction within the can is complete. Intermittent spray cooling continues with a further period in a cooling pit in which the cans are totally immersed in water. The cans are then discharged to packing tables at a temperature of approximately 95 deg. to 100 deg. Fah.

The height of the machine varies according to the maximum processing temperature required for the particular product; for 240 deg. Fah. it is about 35ft high and 250 deg. Fah. it is 45ft high.

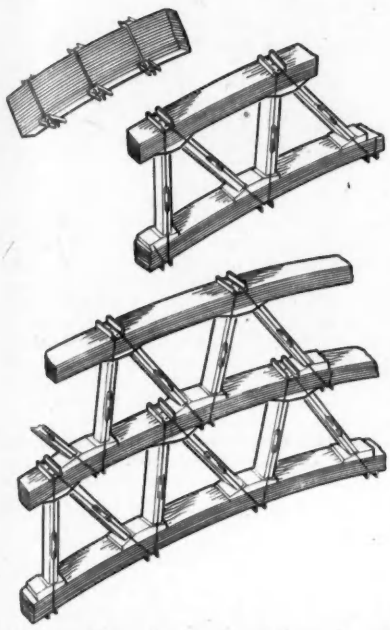
The endless can carrier of the machine consists of a series of beams of special section, which carry the cans in double rows, each row containing some twelve to fourteen cans end to end. These beams are bolted to twin roller chains operating in a track to convey the cans in a continuous line through the complete process. With twenty-four to twenty-eight cans arranged abreast on each double row of the carrier the chain speed through the machine is reduced to about 3·5ft per minute, and this is sufficiently slow to obviate the risk of misfeed. Even should misfeed occur it would interrupt the operation of the machine or cause a jam. A twin feed and discharge mechanism operates in synchronisation with the vertical movement of the can carriers. It consists simply of an endless belt running over two large-diameter pulleys, the top being the feed level and the bottom (and reverse side) being the discharge level. The moment of feed and discharge is controlled by the can carrier in conjunction with a can interrupter device operated by the main chain.

A typical machine working on canned garden peas has an output from 200 to 600 cans per minute over a wide range of can sizes. Similar smaller machines, working at lower temperatures on fruit processing, have outputs from 65 to 520 cans per minute. The makers state that some fifteen variations of four standard machines are available.

OIL PRODUCTION WALL MAP.—The Petroleum Information Bureau, 29, New Bond Street, London, W.1, has published a coloured wall map, price 2s. post free, which gives the world oil production for 1954, linked with the intake capacity at the end of the year by refineries processing crude oil. The locations of producing and refining centres are marked and a diagram shows the main world oil movements, while a graph illustrates the growth of production. Tabular statements record the production and refining capacity of the different countries which are placed in groups based upon geographical position.

Centering for Arched Bridges and Roofs

We illustrate herewith a method of constructing centering which has been used for the construction of a number of arched bridges in Italy. The method is applicable to any falsework of arched shape It consists, basically, in taking a "bundle" of boards and bending them to the required arched shape, thus inducing a heavy bending moment in each board in the bundle. The bundle is then clamped, using bolts bearing on short lengths of channel iron, as shown in our first diagram. This clamping has the effect of holding the "bundle" in its deformed position, as a single prestressed structural element. Where spans are large, or the working loads heavy, the system can be elaborated with two or three elements braced together, as shown in the second and third diagrams; in these cases, turnbuckles and cables are used to apply the compressive forces.

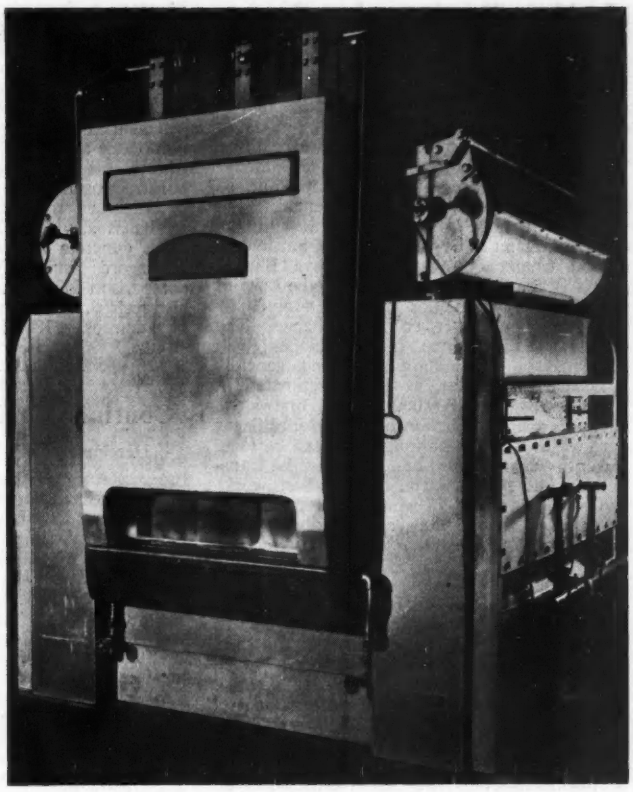


Arched centering elements formed from clamped "bundles" of timber boards

The centering for the Varazze bridge in the province of Genoa is shown in the photograph reproduced below. Here, the span of the arch is 101m and the rise 30m. As may be observed, the more complicated "two-tier" arrangement of the centering, shown in our third diagram, has been employed. In this case, the lower braced section is formed on the ground, and erected as a complete element, as already described, but the upper tier is added *in situ* after the prefabricated single-tier arches have been erected and braced together. It may also be noted that the centering ribs are substantially cross-braced to form three pairs of arches, with adequate strength to resist buckling. In this particular case three reinforced concrete arch ribs are to be cast, and the construction of the rib shutters is shown in progress on the left-hand side of the illustration The total volume of concrete supported by the centering is 1200 cubic metres. There are 160 cubic metres of timber in the centering assembly. Each arch element erected on the ground weighed 15 tonnes, and had a developed length of 130m.

The design calculations for the centering are developed from an equation involving the force required to pull a board out, from between two others, with a given compressive load acting across the three. From this, the spacing required for the bolts or ties can be computed, and hence the stresses in the timber before and after application of the dead load obtained. This system of centering has been developed by the Italian firm, Dott Ing Eusebio Cruciani, the agents in this country and the Commonwealth being Approved Inventions, Ltd., 177, High Street, Orpington, Kent.

Centering for the Varazze Bridge in Northern Italy. The arch has a span of 101m and a rise of 30m



Forge furnace fitted with atmosphere control equipment for the prevention of scale formation

Atmosphere Control System for Furnaces

A particular trouble experienced in fuel-fired furnaces when heating steel blanks and billets, such as for forging purposes, is scale formation and resultant metal loss. Oxidation troubles are also encountered in many heat-treatment processes, but these troubles can be overcome if a sufficient concentration of carbon monoxide can be maintained in the furnace atmosphere. A recent development in this connection made by the Incandescent Heat Company, Ltd., Smethwick, Birmingham, is known as the "Equiverse" system. The equipment used in this system enables steel to be heated to forging temperatures and above with a high percentage of carbon monoxide in the furnace atmosphere.

In the "Equiverse" system a furnace is fitted with special regenerator and "thermal pulsator" equipment, which, the firm states, provides the necessary atmosphere to prevent oxidation of work. A town-gas-fired forge furnace fitted with the equipment can be seen in the photograph we reproduce on this page. The metallic tube regenerators have a rapidly reversing cycle and they serve to preheat the incoming combustion air to between 900 deg. and 1000 deg. Cent. It is stated that this maintains combustion with a carbon monoxide content of about 14·5 per cent. A proportion of the gases discharged from the furnace is recirculated through the regenerators, and this ensures that all the carbon monoxide in the furnace atmosphere is completely burnt after having served to protect the work under treatment. The system gives a high degree of heat recovery, the combustion efficiency being such that when a furnace is operating at 1300 deg. Cent. the waste gas temperature is below 200 deg. Cent.

The equipment for the new thermal cycle can be fitted to any fuel-fired furnace, and the makers state that there is no metal loss or scale formation while heating plain carbon or alloy steels at temperatures up to 1300 deg. Cent during soaking periods ranging from a few minutes up to several hours.

Refractory Concrete.—We have received from the Lafarge Aluminous Cement Company, Ltd., 73, Brook Street, London, W.1, a booklet containing data for concretes made with Ciment Fondu. The booklet is entitled "Mix Data and Conversion Tables for Use with High Alumina Cement." The company has also published a list of suppliers of materials for refractory concrete, and a folder showing some applications of that material in the iron and steel industry.

Indian Engineering News

BY OUR INDIAN CORRESPONDENT

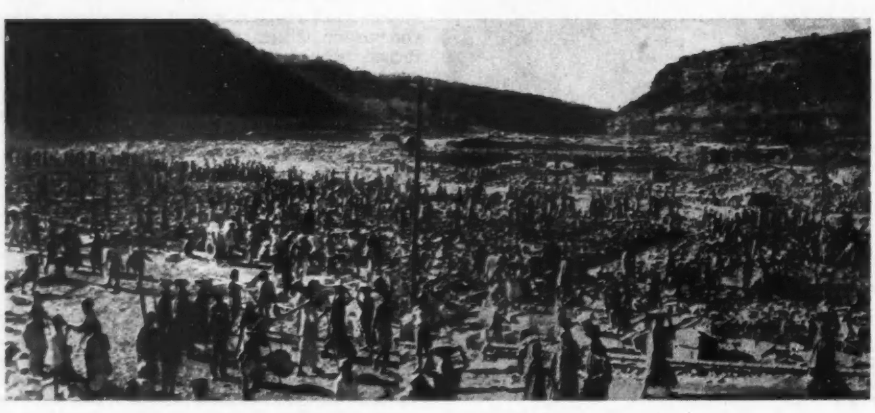
Chambal Valley Scheme

Most of the big dams in India, that is, dams over 200ft high, are either in mass or cyclopean concrete but there are a few exceptions. Two of the more important dams in the Damodar Valley, for instance, are earth dams, and so is the Hirakud dam on the Mahanadi. But the only major masonry dam now under construction in India is the Gandhi Sagar dam of the Chambal Valley in Madhya Bharat, and it is being built very much on the lines of mass labour construction methods adopted by the Chinese on their river valley schemes. The Chambal Valley, when fully developed, will help irrigate 1·4 million acres and generate 204,000kW of power, at a cost estimated at Rs.72 crores (£54,000,000). The first stage envisages the construction of the Gandhi Sagar dam with its power station, the Kotah barrage, the entire canal system and a part of the transmission line system. The cost of these works will be Rs.48 crores, of which Rs.22 crores will be spent on the canal system and about Rs.10 crores on the power station and the transmission system.

The dam, work on which began in March last year, is a gravity masonry structure, 204ft high and 1682ft long. The stone is the local hard quartzite and it is cemented with red mortar, consisting of four parts cement, one part sand and one part surkhi (fine brick powder). The only labour used is manual labour for stone-cutting, transporting the dressed stone piece by piece to the site, and placing it, as can be seen from our illustration. The labour force is roughly 5000 and the dam is expected to be completed in about seven years' time. The dam proper will cost Rs.8·9 crores and is supposed to be one of the cheapest in India. It will store an acre-foot of water at a cost of Rs.18 (27s.) as against the normal Indian figure of Rs.75.

"Concrete *v.* masonry" has always been a subject of debate for Indian engineers, a subject that recurs every time a dam comes up for construction. The Rihand dam, in Uttar Pradesh, and the Koyna in Bombay, will probably be concrete dams, but the matter is yet to be settled and the tenders call for both modes of construction. Writing recently in the *Indian Journal of Power and River Valley Development*, Mr. M. S. Thirumale Iyengar, Chief Engineer, Hirakud Dam Project, has said, "While it is beyond doubt that concrete has some material advantages from the point of view of rapid execution and certain constructional features in very high dams located in deep gorges of short widths, it is strange to find some of our engineers plumping for concrete for dams that are long and have ample working spaces for speedy rubble-in-mortar construction. It must be admitted that at best our concreting will be an inferior imitation of American methods. It is said that the strength of the masonry is the strength of the mortar that is in it. In a dam where the stones are placed by hand in a particular manner with interstices filled with spalls and mortar, the whole rubble stone masonry becomes a homogeneous section not at all comparable to a section of masonry in buildings. When I say that the Mettur dam, in the south, which is built of stone masonry, is the driest dam in the world, nothing more need be said about the merits of masonry for dams."

This is not, however, the official view. A committee appointed by the Government to go into the merits of masonry and concrete in dam construction has just reported that "both types of construction materials have their respective merits as also their limitations, the committee holds concrete as a superior building material as regards uniformity and dependability in comparison to stone masonry." The committee also feels that stone masonry is not suitable for high dams, say, 100ft high or more.



Work in progress on the stone masonry dam in the Chambal Valley project

Continental Engineering News

Development of Electric Power in Sweden

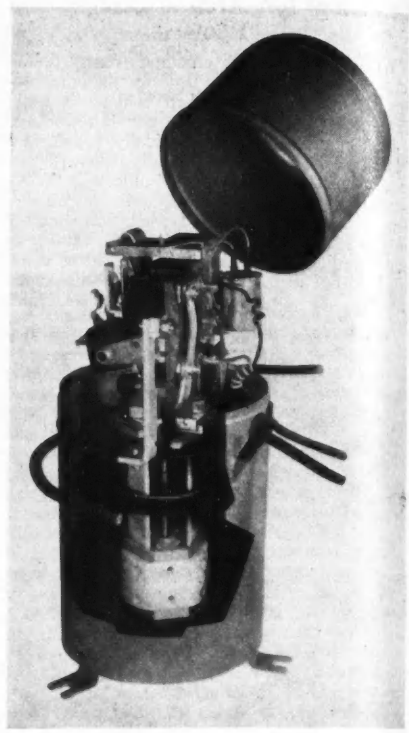
According to the Swedish State Power Board, the consumption of electric power in Sweden has increased more rapidly than was estimated at the beginning of the present decade. In the fiscal year 1954–55, the consumption rose by 2000 million kWh, as compared with an increase of 1450 million kWh in the previous year. It is now envisaged that the annual increase during 1954–61 will amount to some 1700 million kWh (the original forecast indicated an average increase of 1200 million kWh per annum for 1950–55, and of 1500 million kWh for 1955–60). Present schemes for power development, therefore, have to be speeded up.

The Board accordingly proposes to complete the 75MW Långbjörn plant on the Ångerman River by 1959, one year earlier than originally intended, and to put the first set of the 140MW steam generating station at Stenungsund, north of Gothenburg, into operation at the same time. In addition, a 40MW gas turbine plant, stated to be the largest of its kind so far projected, is to be built at Västervik, on the east coast. The 130MW plant at Porsi, on the Lule River in north Sweden, is to be completed by the autumn of 1960. Altogether, the Board is asking for appropriations of Kr.337 million (£23,250,000) for the fiscal year 1956–57. Of this sum, Kr.190 million are to be spent on new power stations and Kr.120 million on transmission lines and other equipment.

Automatic Liquid Starter

The accompanying illustration depicts an exploded view of the "R.L.V." liquid-vapour starter (Brevet Bérard), made by Association des Ouvriers en Instruments de Précision (A.O.I.P.), 8–14, rue Charles Fourier, Paris (13e). Being a stepless and fully automatic device, it is stated to possess advantages over the conventional wound-resistance design by virtue of its smooth action, smaller size for a given capacity, and cheapness of maintenance. Its action depends essentially on the great difference in electrical resistance between an electrolyte and its vapour, which is of the order of 1 to 50.

In the present design, the starter assembly



Liquid starter unit, showing cell at bottom and time-delay short-circuit device on top

is supported at the centre of a container fitted with approximately 4 litres of sodium or potassium carbonate solution. It consists of three cells formed as cavities in a plastic moulding, each cell having a capacity of a few cubic centimetres and communicating with the liquid outside. Three nickel-plated copper strips covered with plastic insulation connect to the three phases of the wound rotor of the induction motor, the bare ends of the strips forming one set of electrodes, the other being in the form of a hexagonal ring embedded in the moulding, this ring being at the star point of the circuit.

On switching on to line voltage sufficient heat is generated inside each cell to vaporise its contents and thereby increase its resistance many times. The time required for this to occur is said to be less than one-fiftieth of a second at standard frequency. In consequence, the initial starting current is limited to two or three times the nominal motor current, while without the starter it would be equal to the motor short circuit current, i.e. six to nine times the nominal value. Maximum resistance having thus been reached, the voltage across the cell drops as the motor gathers speed, and in consequence the current, and hence vaporisation is more and more diminished until a threshold is reached at which the latter stops altogether. Surplus vapour escapes through suitably dimensioned holes in the walls of the cells, into the surrounding liquid, where it is condensed. Fresh liquid is drawn in and all resistance falls, approximately exponentially, to its initial value. When this point is reached all the cells are short circuited by a "Thermistor" operated delay switch.

The unit can be adjusted to suit motors ranging from 5 h.p. to 40 h.p., while for powers up to 300 h.p. several units may be placed in parallel or in series-parallel. In some such cases, only one short circuiting switch of 125A capacity is required. Adjustment of the cell volume and electrode area to suit the motor horsepower, as well as the prevailing mains voltage, is carried out by inserting calibrated strips of plastic. As the evaporation of electrolyte is proportional to the power absorbed by the motor, the cell resistance is self-regulating, producing smooth acceleration under all conditions of load and inertia. As an example of the robustness of the equipment, the firm states that 75,000 starts of an 18 h.p. motor were obtained at the rate of one start each minute and a half.

Industrial and Labour Notes

Autumn Budget

On Wednesday of last week, the Chancellor of the Exchequer, Mr. R. A. Butler, presented a supplementary Budget in the House of Commons. Its main proposals are increases in purchase tax from 25 per cent, 50 per cent and 75 per cent to 30 per cent, 60 per cent and 90 per cent respectively; an increase from 22½ per cent to 27½ per cent in the tax on distributed profits; an increase in telephone rentals and subscribers' call charges, and an increase in certain postal rates.

The Chancellor stated that the Government must exercise restraint in its own programmes of capital expenditure and it was therefore intended to postpone some Government office building projects. It was also proposed to effect economies in the subsidised housing programmes of local authorities. About the nationalised industries, the Chancellor said that the gas industry would make do with older equipment, such as carbonisation plant, for a longer period, and would be able to reduce its expenditure this year by something approaching £3,000,000. The Central Electricity Authority had asked the area boards for an all-round percentage cut in their expenditure in the current year, and even in the priority field of generation the Central Electricity Authority had been able to postpone certain less vital projects while pressing on urgently with the nuclear power programme. In both the electricity and the gas industries, the Chancellor said, what was called "promotional expenditure" was being cut back. The coal mines, the Chancellor continued, must have their full investment, but the National Coal Board was pursuing the possibility of some saving by deferring projects such as brickworks and office buildings which did not affect output. The Chancellor added that the modernisation and re-equipment plan for British Railways was at an early stage of its development and did not, therefore, at present, involve any substantially increased demand on labour and resources. The British Transport Commission, however, was well aware of the general needs of the economy, and would have those needs in mind in carrying through its programme.

In presenting his proposals, Mr. Butler said that the problems the country was facing were not problems caused by a slack or enfeebled economy. We were moving on the tide of a vigorously growing expansion, which was outstripping the resources available to maintain its strength. The problems of the British economy, the Chancellor declared, demanded a dual policy combining both incentive and restraint. When a productive machine was working at such brimful capacity it became easier not merely to obtain higher money incomes but also to pass on in higher prices the increased costs which resulted. Both costs and prices, the Chancellor said, had been gradually edging upwards, reflecting the continuing rise in personal incomes. This led to social strains at home, and abroad it threatened the competitive power of our exports in a world market where prices were becoming increasingly keener.

The Future of Industrial Relations

On Thursday and Friday of last week, the British Employers' Confederation held a conference in London to discuss the future of industrial relations. It was attended by over 200 delegates from employers' organisations which form the Confederation's membership.

The conference was private, but at its conclusion a statement about some of its deliberations was issued to the Press. This statement said that the economic background was reviewed, and that there was full agreement on the need to relieve the excessive pressure of demand on the nation's resources and to increase industrial efficiency. In the discussion on this matter, the statement continued, it was pointed out that the Ministry of Labour's overall figures of unemployment and outstanding vacancies did not reflect the extent of the shortage of workers in particular industries and occupations. Outstanding vacancies were naturally greatest where unemployment was lowest, and exporting industries were increasingly finding themselves unable to afford increased labour costs. The raising of wages in industries producing for the home market tended to force up wages in the exporting industries, or, in default of so doing, attracted workers from those industries. Raising prices in the home market increased the cost of living and stimulated demands for wage increases, and it also increased the charges for essential supplies and services to all industries, including exporting industries. The continued rise in wages, the conference decided, was not being matched by a corresponding rise in production. Another matter discussed was the role of trade unions in the future of industrial relations. It was pointed out that full employment had thrown up a new set of problems and that the position of the shop steward had been strengthened relatively to that of trade union officials. The conference condemned "the retrospective payment of strike pay by the union concerned" where an unofficial strike took place, and restrictive practices were deplored as hindering measures to increase industrial efficiency.

In its consideration of the role of employers' organisations, the conference agreed that individual employers could easily damage each other's interests by short-sighted actions which, in the long run, harmed themselves as well. There was discussion on the need for the further strengthening of employers' organisations, and it was emphasised that since the war many of them had embarked on new activities. These included the development of training facilities for operatives and foremen, the provision of advisory and other services concerning safety and health, the introduction and extension of work study, and increased attention to public relations on behalf of the industries they represent. One suggestion made at the conference was that employers' organisations would more readily improve their methods of working, extend their membership and build up a habit of increased co-operation by the development of such common services for their members than by any other way.

Changes in Wage Rates

The Ministry of Labour has stated that, during September, changes in wage rates reported to have come into operation in the United Kingdom resulted in an aggregate increase of about £146,000 in the weekly full-time wages of 412,000 workpeople. There was also a decrease, aggregating £250, in the weekly wages of 10,000 workpeople. This decrease, of course, operated under sliding scale arrangements based on the index of retail prices. It affected workers in the iron and steel industry in a few districts, and iron-ore miners and limestone quarrymen in Cumberland. In the first nine months of this year, changes in wage rates led to an aggregate increase of £4,580,300 in the weekly full-time wages of 11,389,000 workpeople. In the comparable period of last year 8,406,000 workpeople received wage increases aggregating £2,646,000. The changes in wage rates reported in September made no difference to the index of rates of wages (June 30, 1947=100). The index for all workers stood at 153, the same as in the two preceding months.

Industrial Disputes

During September, 251 stoppages of work on account of industrial disputes in the United Kingdom were reported to the Ministry of Labour. In addition, there were twenty-eight stoppages, which had started before September, still in progress in the early days of that month. In these 279 stoppages, the Ministry of Labour says, 67,500 workers were directly and indirectly involved and there was a loss of 227,000 working days. Of the total, 202 stoppages occurred in the coal mining industry, involving 29,800 workers and causing a loss of 63,000 working days. The Ministry's figures show that 254 stoppages of work through disputes ended during September. Of that number, ninety-five directly involving 17,000 workers lasted not more than one day, while nineteen, directly involving 6500 workers, lasted for more than six days. In the first nine months of this year, 1778 stoppages of work through disputes were reported. In them, 553,400 workers were involved, the aggregate number of working days lost being 3,199,000.

Export of Iron and Steel Goods

The Board of Trade has stated that the open general licence which authorises the export of certain iron and steel goods valued at more than £20 a ton to any destination other than China, Macao, North Viet Nam, or Tibet, is being revoked. It is being replaced by a new open general licence which raises this value limit to more than £25 a ton. This licence will operate on and from November 9th, and individual licences will be required for exports where the value is £25 a ton or less. The iron and steel goods are those specified in Group 6 (2) of the first schedule to the Export of Goods (Control) (Consolidation) Order, 1955. Inquiries about the licence should be made to the Board of Trade, Export Licensing Branch, Atlantic House, Holborn Viaduct, London, E.C.1.

Opencast Coal Contract

The National Coal Board has announced that a contract for working the Radar opencast site, in Northumberland, has been let to James Miller and Partners, Ltd., Edinburgh. This site, it is stated, is the third, and biggest, of the five very large opencast workings programmed by the National Coal Board, and it is expected that between 8,000,000 and 10,000,000 tons of coal will be produced from it. The Board points out that, during the past summer, the output of opencast coal in this country has been nearly 20 per cent higher than in the comparable period of last year. Sites like the Radar, the Board adds, will enable this high rate of output to be maintained, thus helping to reduce the need for coal imports.

When the maximum output is achieved at the site, it is expected to be at a rate of between 750,000 and 1,000,000 tons a year. The coal will be cleaned and screened at the Widdrington and Linton disposal centres.

Winter Fuel Supplies

The Minister of Fuel and Power, Mr. Geoffrey Lloyd, told representatives of the National Production Advisory Council on Tuesday that the Government had made plans to ensure that coal supplies to essential services, such as power stations, gasworks, iron and steel plants, and railways, were maintained during the winter. He added that what was required in the national interest was "a combined operation on two fronts—a resolute effort to increase coal production and an intensified drive for coal economy."

The Minister said that stocks at the beginning of this coal winter would probably be as high as 19,000,000 tons, but he emphasised that there must be no complacency because of the large stocks. The favourable stock position was mainly the result of the warm summer and the Government's decision to import foreign coal; the position had not been brought about by better output from the deep mines. Bad weather, combined with a continuation of disappointing output, would lead to difficulties, and imports, Mr. Lloyd said, could not be increased without interfering with imports of iron ore, and that could not be done.

The latest figures published by the Ministry of Fuel and Power show that last week there was a slight improvement in total coal production, although there was no increase in deep-mined output. The total output for the week, deep-mined and opencast, was 4,642,100 tons. In the first forty-three weeks of this year coal production totalled 181,470,100 tons, compared with 184,613,400 tons in the corresponding period of last year. Coal imports (in the first forty-two weeks of this year) were 9,575,200 tons, against 1,910,000 tons in the comparable period of 1954.

National Machine Tool Show at Chicago

BY OUR AMERICAN EDITOR

No. I

The American Machine Tool Show was held at the International Amphitheatre in Chicago from September 6th to September 17th and was attended by well over 100,000 visitors. The exhibition was organised by the National Machine Tool Builders' Association, and this article reviews certain advances in respect of design, construction and performance of particular interest.

THE Machine Tool Show recently held at the International Amphitheatre in Chicago included 175 participating companies exhibiting over 500 machine tools in four halls having a total floor space of nearly 500,000 square feet. The exhibition always is a major event in the United States both from a mechanical engineering and a production engineering point of view, and this year's display may be considered a real success. Apart from an unprecedented attendance, there was a strong buying interest to be noted which is expected to lead to considerable orders for the American machine tool manufacturers in the near future. It has been said that three important points contributed to the greater success of the 1955 show compared to the one held in 1947 : to-day, machine tool builders are not competing with the large stocks of Government surplus equipment which were on the market in 1947 ; the term " automation " did not exist eight years ago and now has caused much excitement and interest among engineers attending the exhibition, and the current business boom in America tends to encourage heavier buying of machine tools, both for expansion and replacement.

From a technical point of view, the 1955 machine tool show can be summed up in terms of the following trends : (1) More rigid machine tools with higher speeds and greater horsepowers to take advantage of cemented carbide cutting tools ; (2) widespread application of Ward-Leonard d.c. " package " drives in place of conventional squirrel-cage a.c. motors, to obtain infinitely variable speeds ; (3) increasing use of electronic circuits on speed selection, tool feeding, operation cycling and copy-tracing devices, often in place of previously used hydraulic mechanisms ; (4) availability of optional programme control accessories for standard machine tools, to facilitate automatic cycling with appropriate selection of speeds, feeds and operations, and (5) considerable accent on " automation " single-purpose machine tools of special design, including automatic loading, positioning and transfer devices and built-in gauging and feed-back systems.

As will be appreciated, the wide field covered by the exhibits and their variety makes it impossible to give more than a general idea of the scope of the machine tool show in this article. For this reason we have selected for review a variety of representative machine tools which are of new design or incorporate improvements, and we illustrate some other typical machines. It is of interest to note that in view of the close ties which most American machine tool manufacturers have with either associated works or distributors in the U.K., readers are likely to see many of the machines described here on display at the machine tool exhibition to be held in London next summer.

The Warner and Swasey Company

A new item of equipment which was included amongst the turret* lathes exhibited by the Warner and Swasey Company, Cleveland, Ohio, was the hydraulic contour tracing attachment for contour turning and facing work which is illustrated in Fig. 1. Using either flat or round templates as the master pattern, the hydraulic tracer provides accurate control of both rough and finish cuts during operation. The unit is designed to be mounted at a 45 deg. angle on the rear of the cross slide of the turret lathe and is intended for operation with the machine spindle rotating in the reverse direction. According to the company, reverse rotation of the spindle causes the cutting pressure to be concentrated downwards on to the cross slide and rear bedway, thus obtaining greater rigidity and accuracy.

Actuation of the tracer slide is accomplished through the use of a large hydraulic cylinder powered by a separate hydraulic pump. The tool slide actuating cylinder has a 6in stroke, providing a maximum effective cutter travel of 4in, thus allowing contour facing of parts having a maximum height difference of 4in or contour turning of parts having a maximum difference in diameter of 8in. The 45 deg. angle of the contouring slide permits the machining of contours, tapers and stepped diameters which increase in the direction of trace, up to and including 90 deg. shoulders. The extremely sensitive response of the tracer is obtained by means of a differential hydraulic system regulated by a precision-built stylus control valve. The tracer stylus itself,

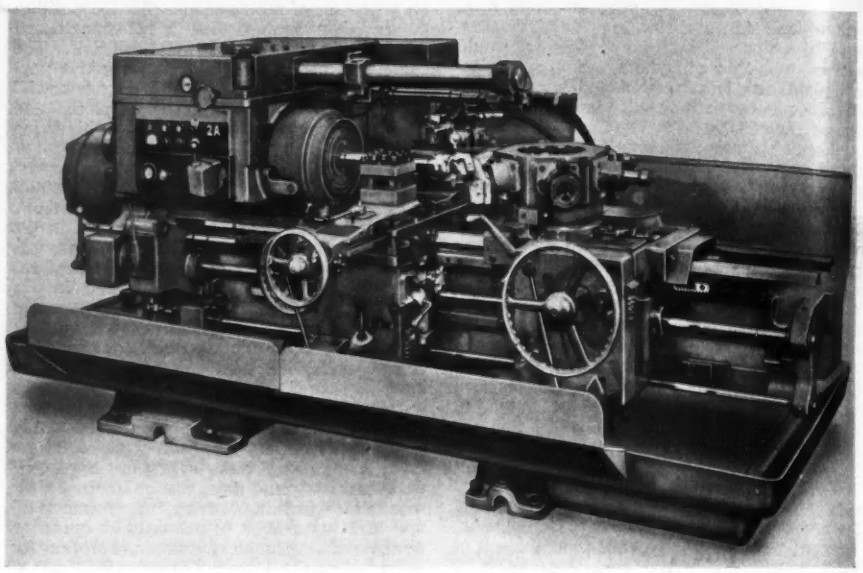


Fig. 1—Warner and Swasey No. 2A turret lathe, with hydraulic contour tracing attachment

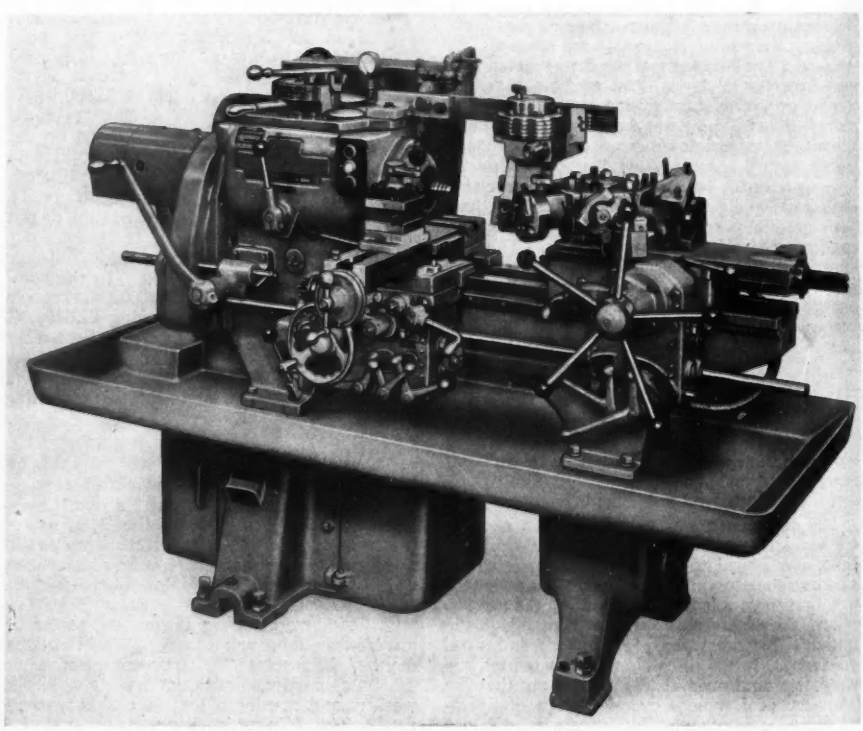


Fig. 2—Warner and Swasey No. 3 turret lathe, with progressive step turning attachment

* Note : In accordance with American terminology, no differentiation is made between " capstan " and " turret " lathes

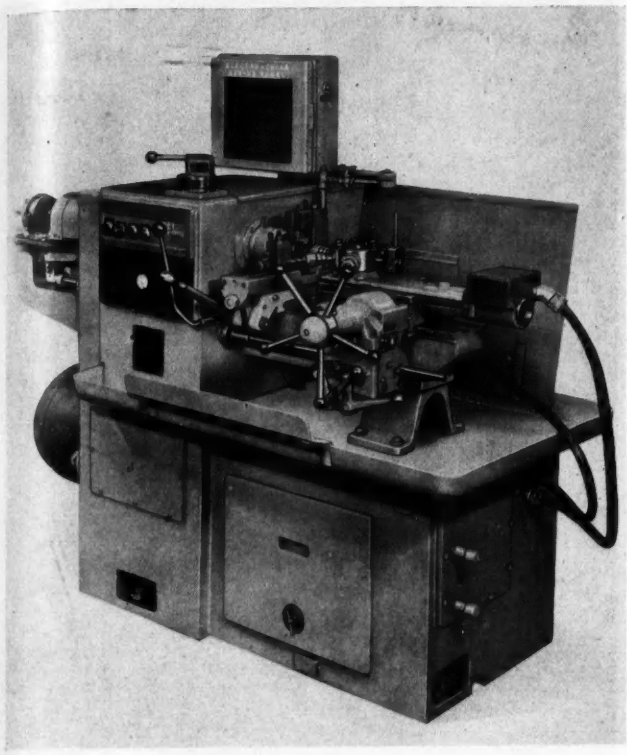


Fig. 3—Warner and Swasey No. 1 electro-cycle turret lathe with automatic spindle control panel

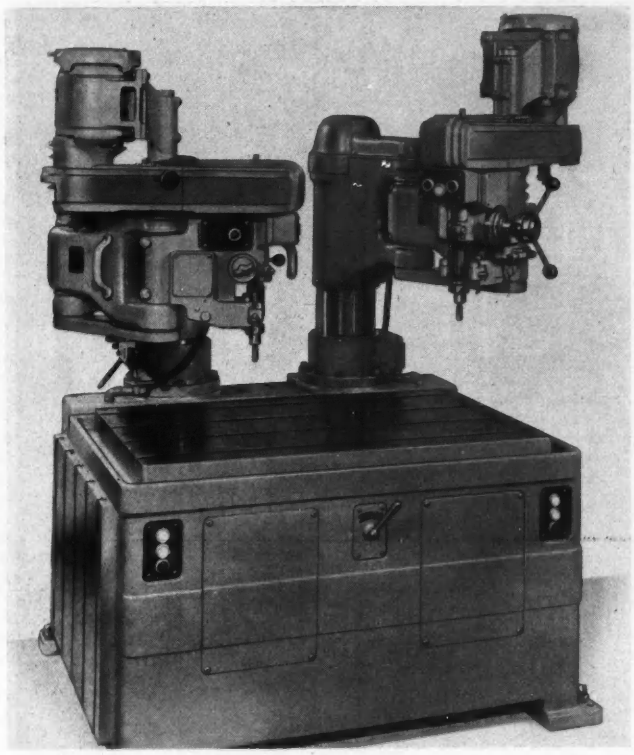


Fig. 4—Warner and Swasey No. 11RD dual-head precision tapping and threading machine

which actuates the control valve, utilises a flexure pivot to eliminate any lost motion or play during operation, thus facilitating an accurate reproduction of the master pattern under a variety of cutting conditions.

Flat templates are mounted in a long clamping bar which is attached with brackets to the overhead pilot bar of the unit. Micrometer adjusting screws permit an accurate alignment of the template with the spindle axis. Centre adapters, which can be inserted into the mounting bracket in place of the flat template holder, are used to hold turned patterns. For contour facing, a special template holder fits into the mounting bracket and holds the template in a horizontal position at a 90 deg. angle to the spindle axis. Changing from contour turning to facing operations only requires the installation of the proper template. No changes are required in the hydraulic tracer unit itself. The setting-up of the tracer to finish diameters is facilitated by a micrometer adjusting screw which controls the relation of the stylus to the cutter. Three stops of different lengths, incorporated in the adjusting screw mechanism, permit up to four rough cuts to be taken prior to the final finish cut without any change in cutter settings. Heavy metal removal, together with the ability to hold close tolerances and good finish, is accomplished through the use of a two-position hydraulically indexed and clamped turret which holds both a rough cutter and finish cutter. The cutting edge of the finish cutter is preserved for light finishing operations only, with heavy stock removal being handled exclusively by the rough cutter. When not in use, the tracer unit can be retracted to its rearmost position and shut off with a switch, thus permitting the machine to be operated as a standard turret lathe without interference.

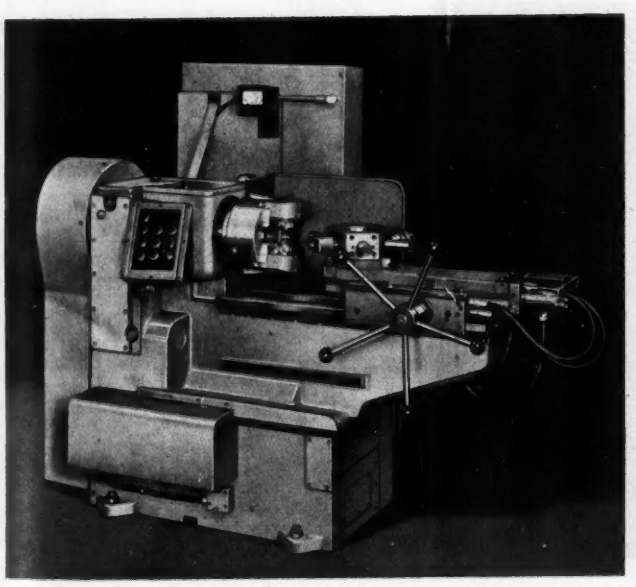


Fig. 5—Gisholt No. 3 "Electram" turret lathe with power indexing chuck

An interesting box tool for progressive step turning was shown by the Warner and Swasey Company mounted on one of the turret faces of a No. 3 universal ram turret lathe, illustrated in Fig. 2. The tool is known as the "progressive step turner," and was designed particularly for the small shop which turns a variety of stepped shafts in small lots and, therefore, requires a fast and flexible set-up at low cost. The progressive step turner can be set up in only about a quarter of the time usually required by conventional roller turners, and the tool imparts an extremely fine finish to the work. Accuracy is held consistently on piece after piece, due to the elimination of all lash in the design of the tool. With a bar capacity of 1½in the turret lathe shown offers a range of twelve spindle speeds, which are obtained through the use of a six-speed headstock and a two-speed, 10 h.p. drive motor. No gear shifting is necessary in the majority of cases, since four speed changes are instantly obtained by means of the high-low clutch and the high-low motor control push button.

The progressive step turner incorporates a cutter holder mounted on a pendulum arm which is suspended from a large shaft equipped with roller bearings. The movement of the arm is controlled through a reduction gear and a rack and pinion arrangement by means of four simple preset micrometer dials situated at the top of the attachment. When the first four diameters have been selected on the micrometer

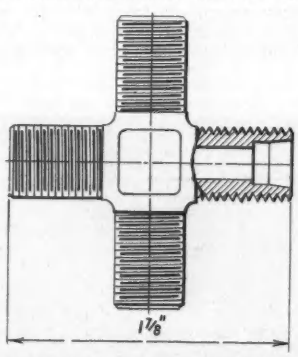


Fig. 6—Detail of steel union cross-tube fittings

dials, the fifth diameter is obtained by means of a stop screw situated at the end of the lower rack. Each of the micrometer dials is notched and equipped with roller pawl arms. Turned lengths are established on the workpiece by adjusting movable shoes which are clamped in slots in the flat overhead bar of the unit. The movable shoes trip the pawl arms of the dials successively as the turner moves longitudinally under feed. This tripping action causes the dials to rotate counter-clockwise progressively, thus moving the cutter to the predetermined work diameters. Resetting of the attachment for the next workpiece is accomplished merely by rotating the dial head clockwise until all pawl arms drop back into their respective positions on the micrometer dials. Thus, the need for templates is completely eliminated.

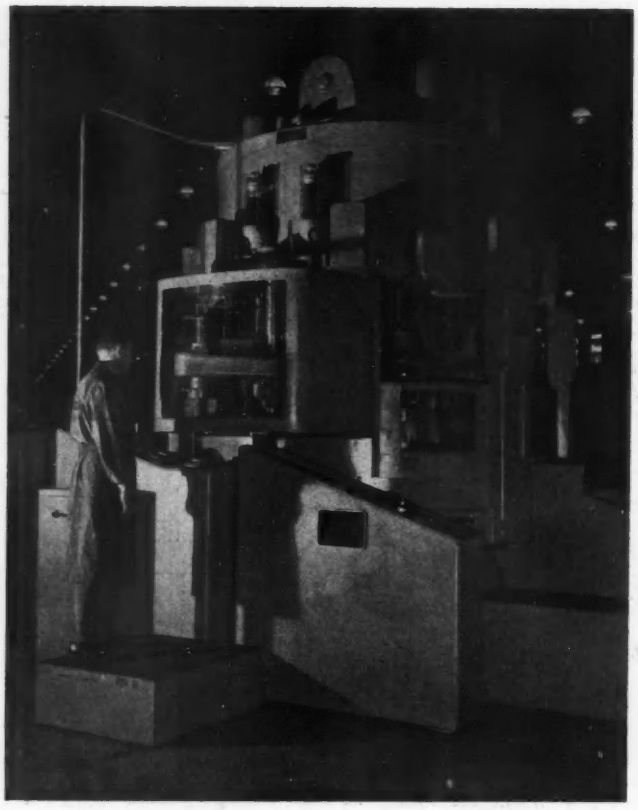


Fig. 7—"Mult-An-Matic" eight-spindle, vertical chucking machine —Bullard Company, Bridgport, Connecticut

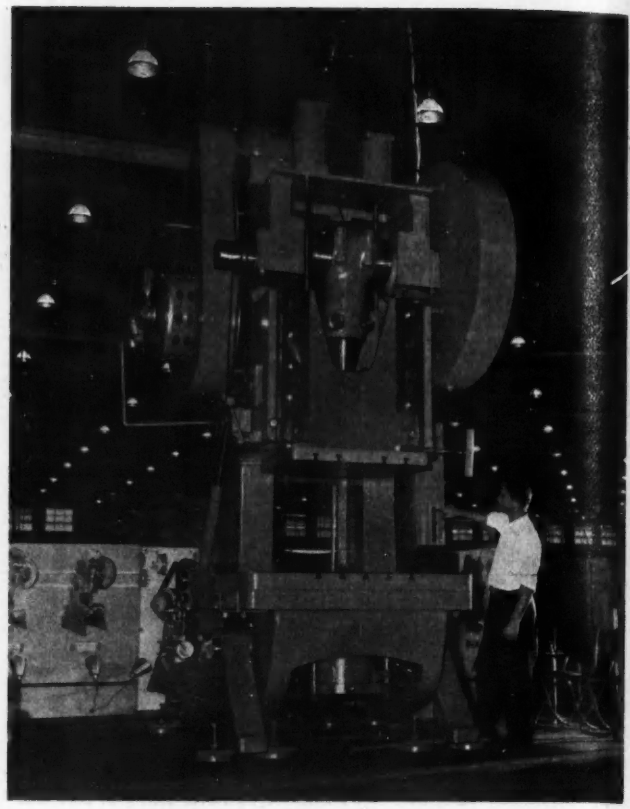


Fig. 8—200-ton open-back, inclinable press with counterbalanced box ram —Ferracute Machine Company, Bridgeton, New Jersey

A new automatic spindle control set-up panel was demonstrated at the exhibition on the company's No. 1 "electro-cycle" ram turret lathe, illustrated in Fig. 3. The unit displayed was seen machining $\frac{1}{16}$in hexagonal nuts from free-machining brass utilising cross slide forming, roll stamping, turret drilling, step counter-boring, recessing and tapping. Such a job normally would be considered for production on a multi-spindle automatic, but in lot quantities of 1000 to 2000 pieces, a fast, quickly set up, easy-to-operate machine such as the No. 1 "Electro-Cycle" often fits the requirements more economically. The machine is designed to meet high-speed requirements on small diameter bar jobs up to $\frac{3}{4}$in diameter. It is equipped with a high-speed headstock and back gears permitting turning speeds up to 4000 r.p.m., with lower speeds instantly available when needed for threading and forming work. A vee-belt drive is used to transmit power from the 3 h.p., two-speed drive motor through a series of quick-change sheaves which provide a wide choice of speeds. Automatic spindle control is utilised for all spindle functions, such as starting, stopping, reversing and speed changes, with changes being handled conveniently on a special toggle switch control panel mounted on top of the headstock. Once the automatic control panel is properly set, the operator has only the cross slide and turret to regulate during the operation of the machine. Six power feeds, ranging from 0·0015in to 0·015in are provided in the turret apron. The operating ease and speed are increased by the use of an electrically powered automatic collet chuck and bar feed which are standard equipment.

Another item of the firm's equipment on display was the No. 11 "RD" dual head precision tapping and threading machine, which is shown in Fig. 4. According to the company, the great accuracy of tapping with this machine is made possible by the use of positive thread lead control incorporating hardened and ground precision lead screws operating in conjunction with solenoid-actuated, replaceable brass guide fingers. The guide fingers, which are hobbed directly on the lead screw, supply accurate and positive thread lead without back-lash or drag. The

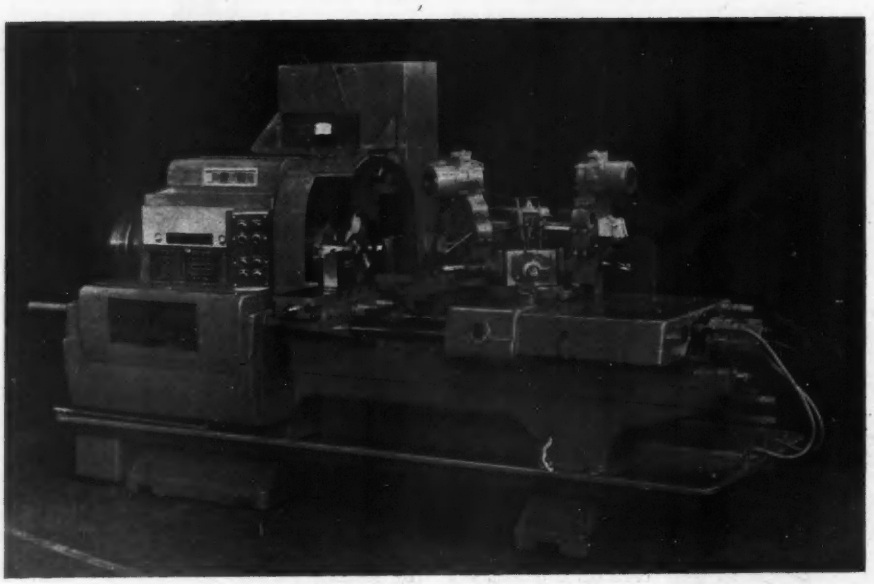


Fig. 9—Gisholt No. 2F "Fastermatic" automatic turret lathe

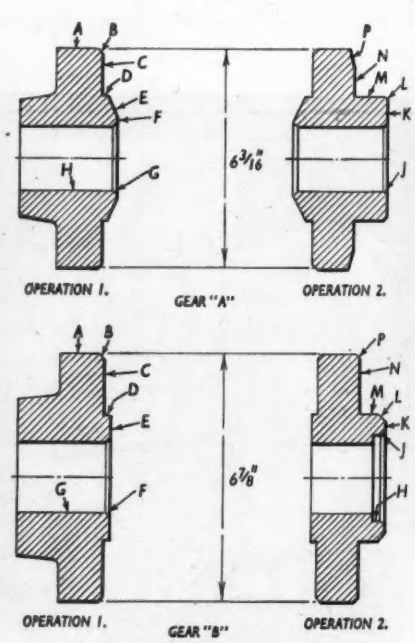


Fig. 10—Detail of stee gear blank forgings

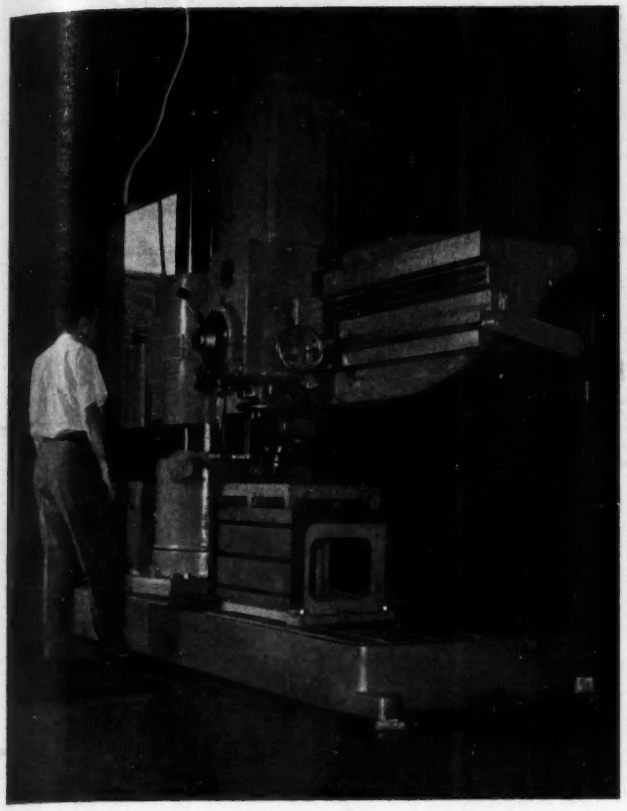


Fig. 11—Radial drilling machine with speed and feed preselector—Fosdick Machine Tool Company, Cincinnati, Ohio

dual head machine is designed to permit precision threading of large-size workpieces. The two tapping heads are raised or lowered hydraulically and independently of each other by readily accessible push buttons situated on the front of the machine base. Working surfaces at the top, left side and at the rear of the base facilitate the handling of a wide variety of work shapes or even two separate workpieces simultaneously. Each tapping head is equipped with a ½ to 1 h.p. rapid reversing motor and vee-belt drive, providing four tapping speeds of 70, 144, 260 and 466 r.p.m. The return speeds are exactly twice the tapping speeds.

Gisholt Machine Company

The stand of the Gisholt Machine Company, Madison, Wisconsin, was one of the largest in the exhibition, covering over 10,000 square feet and containing twenty-five of the firm's machine tools. Fig. 5 shows the No. 3 "Electram" turret lathe, which has a 1½in bar capacity, with a special chucking arrangement to handle small to medium valves, tees, crosses and similar parts requiring machining on two or more ends or sides. The workpieces machined at the exhibition were steel union cross-tube fittings, shown in Fig. 6. All four ends are machined in a single chucking. A "Gisholt-Weatherhead" chuck is used to permit power indexing of the workpieces without stopping the spindle. Standard electrical controls at the rear of the turret ram are preset for each turret station and govern spindle speed, spindle reverse for tapping, spindle stop and single or double indexing of the turret. The hexagon turret tools face, chamfer, centre, turn the outside diameter, drill and form a 24 deg. angle seat and a 15 deg. angle bushing seat at all four ends. The workpiece is indexed in the chuck so that the tools on each hexagon turret station machine all four ends before indexing to the next turret station. To complete the part all four ends are threaded with the spindle reversing each time to withdraw the die holder.

The No. 2F "Fastermatic" automatic turret lathe, which is shown machining a gear blank forging in Fig. 9, incorporates automatic means of setting speeds and feeds and controlling machine functions, which is claimed to cut set-up time by 50 per cent. To demonstrate these properties, two different steel gear blank forgings were completely machined with two operations on each part, as shown in Fig. 10. Gear *A*—operation 1: hexagon turret fully tooled for both operations; stations 3 and 6 by-passed; stations 1, 2, 4 and 5, machine *A–D–G–H*; cross slide tools machine *B–C–E–F*.

Gear *A*—operation 2: changeover; cross slide tools and chuck jaws changed, cross slides set to operate with stations 3 and 6; stations 1, 2, 4 and 5 by-passed; stations 3 and 6, machine *M–J*; cross slide tools machine *K–L–N–P*.

Gear *B*—operation 1: changeover; adjust tools on stations 3, 4, 5, 6 and change on stations 1 and 2 and on cross slides. Chuck jaws and spindle speeds changed and cross slides set to operate with stations 1 and 4; stations 3 and 6 by-passed; stations 1, 2 and 4 and 5, machine *A–F–G*; cross slide tools machine *B–C–D–E*.

Gear *B*—operation 2: changeover; cross slide tools and chuck jaws changed, cross slides set to operate with stations 3 and 6; stations 1, 2, 4 and 5 by-passed; stations 3 and 6, machine *M–H–J*; cross slide tools machine *K–L–N–P*.

Fig. 12 illustrates the Gisholt No. 24 75 h.p. automatic production lathe which was displayed machining the tool joint pins and tool joint boxes shown in Fig. 13. When set up on tool joint pins, the front carriage tool turns *D* while the rear carriage tools face *A–F*, chamfer *B–E* and groove *C*. When set up on tool joint boxes, the front carriage tool turns *C*, while the rear carriage tools face *A–E* and chamfer *B–D*. The tooling is adjustable for various work diameters.

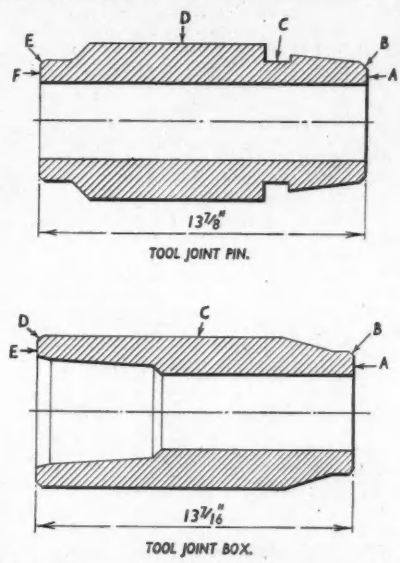


Fig. 13—Detail of forged steel tool joint pin and box

The set-up is fast because all machine functions may be manually actuated by push-button controls. Loading and unloading is a part of the automatic cycle and is performed in the following manner. After machining, the carriages retract, the spindle arbor unchucks, and the tailstock retracts partially. An overhead clamp descends to hold the part while the tailstock arbor unchucks and retracts for clearance. The finished part is raised, the overhead carriage traverses to the front and a second clamp, with the rough part, descends to the position between the spindle and tailstock arbors. The unloading procedure is reversed to chuck the part and machining begins. The overhead carriage traverses to the rear. Both clamps operate, one releasing the finished part, the other one picking up the rough part. The overhead carriage traverses to the front and holds up until machining is completed. The cycle then repeats.

(To be continued)

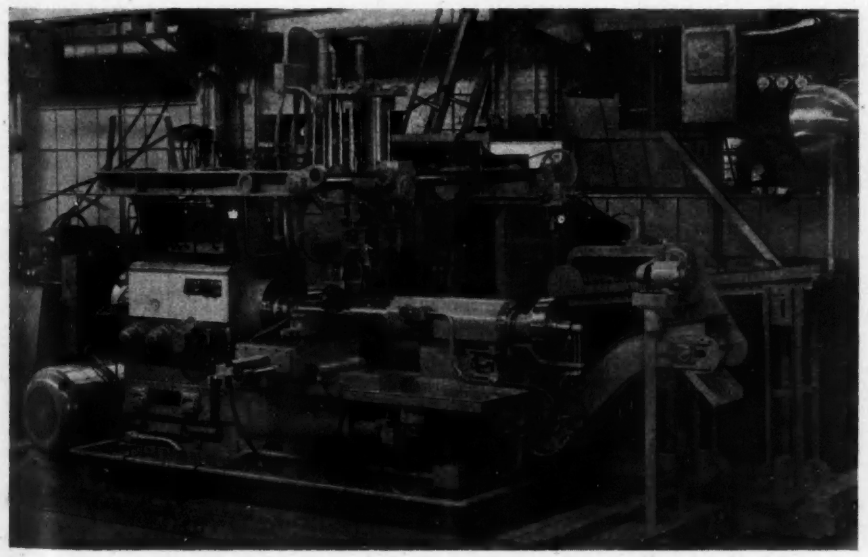


Fig. 12—Gisholt No. 24 automatic production lathe with 75 h.p. drive

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Engineering Researches at the University of Illinois.—We have received from the University of Illinois Engineering Experiment Station four recent publications on researches carried out there. The first is entitled "Research on Highway Bridge Floors at the University of Illinois, 1936–1954," by N. M. Newmark and C. P. Siess. Each phase of a long investigation into fundamental problems of slabs subjected to concentrated loads is briefly described, and references to the more detailed reports are given. Another bulletin on concrete structures is entitled "Strength in Shear of Reinforced Concrete Beams," by A. Laupa, together with the two authors of the previous study.

Personal and Business

Appointments

MR. R. A. HENDERSON and Mr. J. L. E. SMITH have been appointed directors of the Solartron Electronic Group, Ltd.

BAIRD AND TATLOCK (LONDON), Ltd., 14–17, St. Cross Street, London, E.C.1, announces the appointment of Sir Bernard Keen as scientific adviser.

MR. F. THEAKSTON, M.I.Mech.E., a director of Robert Hudson, Ltd., has been appointed London director of the Hunslet Engine Company, Ltd.

MR. J. L. THOMPSON has been appointed manager of the recently-formed British subsidiary of the Square D Company, 100, Aldersgate Street, London, E.C.1.

MR. W. N. COLLINS, marketing director of F. Perkins, Ltd., has been appointed to the British manufacturers' committee of the Society of Motor Manufacturers and Traders.

MR. KENTON REDGRAVE, M.I.Mech.E., deputy chairman and managing director of Russell Newbery and Co., Ltd., has been elected chairman of the export committee of the British Internal Combustion Engine Manufacturers' Association.

MR. W. D. TATTERSALL has been appointed purchasing manager of Kellogg International Corporation, 7–8, Chandos Street, Cavendish Square, London, W.1. He succeeds Mr. J. M. Sexton, who has become purchasing manager of Société Kellogg, in Paris.

THE MINISTER OF HOUSING AND LOCAL GOVERNMENT announces the appointment of Dr. J. S. Carter as chief inspector of alkali, &c., works, in succession to Mr. W. A. Damon, who is retiring from that position on December 4th. Mr. Damon will continue with the Ministry as an adviser.

THE BRITISH TRANSPORT COMMISSION announces the following appointments to the central staff of British Railways :—Mr. H. F. Pallant, freight officer, commercial department ; Mr. G. K. Lund assistant (motive power), operating and motive power department ; Mr. J. C. Loach, superintendent (vehicle and track division), research department.

Business Announcements

THOMAS DE LA RUE AND CO., Ltd., states that its Gas Division will be known in future as the Potterton Division.

NEVELIN ELECTRIC COMPANY, Ltd., has moved to a new factory at Hurst Green, Oxted, Surrey (telephone, Oxted 1450 ; telegrams, Nevelin, Oxted).

BLUNDELL, SPENCE AND CO., Ltd., has moved its head office to York House, 37, Queen Square, London, W.C.1 (telephone, Chancery 6877).

DALLOW LAMBERT AND CO., Ltd., states that its address is now Thurmaston, Leicester (telephone, Syston 86931 ; telegrams, "Dust, Leicester.")

ACBARS, Ltd., Cecil House, 57a, Holborn Viaduct, London, E.C.1, has been appointed sole agent in the United Kingdom for "Graffenstaden" milling machines.

THE POWER PETROLEUM COMPANY, Ltd., states that its Midland branch has moved to King Edward House, New Street, Birmingham, 2 (telephone, Midland 8021).

CANTIE SWITCHES, Ltd., states that its agent in Northern Ireland and Eire is Robert Garmany and Son, Ltd., 33, Queen Street, Belfast (telephone, Belfast 23811).

THE CAPE ASBESTOS COMPANY, Ltd., announces the formation of a subsidiary entitled Caposite Insulations, Ltd., for the manufacture, in Canada, of asbestos thermal insulation materials.

ALLIED NATIONAL CORPORATION, Ltd., states that its address is now Garrard House, 31–45, Gresham Street, London, E.C.2 (telephone, Monarch 3060 ; telegrams, "Alnatcor, Cent, London.").

MONSANTO CHEMICALS, Ltd., states that Hygrotherm Engineering, Ltd., 37, Upper Brook Street, London, W.1, has been appointed sole selling agent in the United Kingdom for its organic silicate heat transfer fluids.

FERRANTI, Ltd., states that it has opened a new research and development establishment for its aircraft equipment department at Westwick, Bagshot Road, Bracknell, Berks. Mr. W. A. Mallinson is the chief engineer and Mr. J. W. Barnes the chief research engineer.

VICKERS, Ltd., states that Mr. E. L. Champness will retire at the end of the year from the position of managing director of Palmers Hebburn Company, Ltd. Vickers-Armstrongs (Shipbuilders), Ltd., is to acquire, on January 1st, the business carried on at Hebburn and Jarrow by Palmers Hebburn Company, Ltd. The management will continue as at present, the business being known as the Palmers Hebburn Works of Vickers-Armstrongs (Shipbuilders), Ltd.

ELGAR MACHINE TOOL COMPANY, Ltd., Hanworth, Middlesex, states that it has been appointed sole selling agent in the United Kingdom for Wiedemann fine boring machines, Hessapp turning and boring lathes, and Hecker and Koch automatic milling machines.

GRIFFIN AND GEORGE, Ltd., states that all London and southern counties orders and inquiries are now dealt with at Ealing Road, Alperton, Middlesex (telephone, Perivale 3344 ; telegrams, "Grifgeorge, Wembley"). The Griffin and Tatlock division at Kemble Street, Kingsway, London, W.C.2, will be closed as from November 7th.

THE AUTOMATIC COIL WINDER AND ELECTRICAL EQUIPMENT COMPANY, Ltd., 92–96, Vauxhall Bridge Road, London, S.W.1, has made an agreement with Blume and Redecker, Hanover, concerning the sales in the United Kingdom and Commonwealth and other overseas markets of the latter company's laminating, wire stripping and coil winding equipment.

Contracts

WESTLAND AIRCRAFT, Ltd., Yeovil, Somerset, is shipping two "Dragonfly" helicopters to Colombo for assembly and use by the Royal Ceylon Air Force.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., Parnell House, Wilton Road, London, S.W.1, has recently received orders for stainless steel strip processing and pickling lines to the value of approximately £900,000, including a £200,000 contract for Sweden.

BRISTOL PNEUMATIC TOOLS, Ltd., The Causeway, Fishponds, Bristol, has received a further order for six duplex two-stage air flow cooled diesel compressor plants for lorry mounting from the Metropolitan Water Board. The company has also received an order from the International Co-operative Administration in Washington, U.S.A., for one of its ATS. 139.PD.2 compressor plants for use in Indonesia.

BABCOCK AND WILCOX, Ltd., has been awarded the boiler contract for the 180MW Mercer steam station which the New Zealand Government is to build on the Waikato coalfield. The consultants for the plant are Messrs. Preece, Cardew and Rider. The contract covers six "Radiant" boilers, each of 300,000 lb per hour evaporative capacity with steam conditions of 635 lb per square inch and 865 deg. Fah. They are fired by pulverised fuel, with three "E" mills per boiler, and are designed to burn two kinds of coal. The boilers will provide steam for six 30MW turbine sets, which are being supplied jointly by the English Electric Company, Ltd., and Metropolitan-Vickers Electrical Company, Ltd. The value of the contract is believed to be approaching £2,000,000. It is planned to have the first two sets in commission by September, 1958.

THE FRASER AND CHALMERS ENGINEERING WORKS of The General Electric Company, Ltd., has received an order, valued at over £600,000, from Colvilles, Ltd., for an ore handling, storage and loading plant, to be installed at General Terminus Quay, in Glasgow, on the River Clyde. Iron ore for the furnaces both at the Clyde Ironworks and the new Ravenscraig Works at Motherwell will be unloaded from vessels berthed alongside the General Terminus Quay. The plant comprises a double line of conveyors from the quayside and storage bunkers at the adjacent rail sidings. Each conveyor line has a capacity of 1000 tons per hour. The quayside conveyors, each over 1000ft in length, discharge to belt feeders, from which further belts cross the roadway and convey for another 750ft to the bunkers. The storage bunkers have a total capacity of 14,000 tons and discharge ore simultaneously to four lines of fourteen wagons each of 35 tons capacity. The discharge to wagons is controlled by hydraulically operated hopper gates.

Miscellanea

CORRECTION.—We are informed that on the Citroen "D.S.19," described in our issue of October 21st, the windscreen and rear window are made of toughened glass.

MR. E. W. SWALES.—We have learned with regret of the death of Mr. E. W. Swales, which took place on Thursday, October 20th. Mr. Swales, who was fifty-eight years of age, was the deputy managing director of Automotive Products Company, Ltd., Borg and Beck Company, Ltd., and Lockheed Hydraulic Brake Company, Ltd.

LOOSENING AND FATIGUE STRENGTH OF BOLTED JOINTS.—Our attention has been drawn to two errors in the illustrations in this article which appeared in our issue of August 26th. In Fig. 2, the dimension g should be the length of the tube only, and in Fig. 4 the symbol for the radius should be ρ, not e, and the scale should have been omitted.

AIRCRAFT TRIALS.—As part of Certificate of Airworthiness trials, a de Havilland "Comet II" (Rolls Royce "Avon") has flown to Africa to find high ambient temperatures. Take-off tests were made at Khartoum in a temperature of 110 deg. Fah. and at Entebbe at an altitude of 3760ft. A number of similar "Comets" are being modified to meet the requirements of Transport Command, Royal Air Force.

OBITUARY.—We record with regret the death of Mr. H. D. Wheeler, which occurred on October 17th, at the age of sixty-three. Mr. Wheeler was chief engineer of Laurence, Scott and Electromotors, Ltd., and had completed forty-six years' service with that company. We have also learned with regret of the death, on October 8th, of Mr. Percy Richardson, a director and former chairman of Foster, Yates and Thom, Ltd., Blackburn.

F.B.I. MISSION TO AUSTRIA.—The Federation of British Industries, after consultation with its counterpart in Austria, has sent a mission to Vienna to offer its help in connection with the re-equipment of factories and public services now restored to Austrian control under the recent State Treaty. The leader of the mission is Sir John Duncanson. The industries to which the mission is devoting particular attention are electronics, machine tools, diesel engines, diesel-electric and electric locomotives, textile machinery, chemical plant, oil drilling and refining plant, and building machinery.

MACHINE TOOL DEMONSTRATION.—A demonstration of machine tools is to be given by the Rockwell Machine Tool Company, Ltd., at the works of Folland Aircraft, Ltd., Hazel Road, Woolston, Southampton. The demonstration will take place from November 23rd to December 3rd. The machines to be demonstrated will include the Thiel range of tool-room machines, a Beer die polishing machine, a Jung fully-automatic internal grinding machine, Werner milling machines, a Smart and Brown lathe, an Aba jig boring machine, an Essex punch shaper, and a number of other machine tools.

LECTURE ON RUSSIAN IRON AND STEEL INDUSTRY.—The Iron and Steel Institute has made arrangements for Sir Robert Shone and Mr. W. F. Cartwright to deliver a lecture on "The Russian Iron and Steel Industry," on Wednesday, November 16th, at 6 p.m., at Seymour Hall, Seymour Place, London, W.1. Tickets of admission to this lecture can be obtained from the Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1. It will be recalled that Sir Robert Shone and Mr. Cartwright were members of the United Kingdom delegation which has recently returned from a tour of Russian iron and steel plants.

SMALL "ARALDITE" EPOXY RESIN ADHESIVE PACK.—We are informed by Aero Research, Ltd., Duxford, Cambridge, that it is now producing a small pack of "Araldite" epoxy resin adhesive for distribution through retail suppliers. It is stated that this is the first time that epoxy resin adhesives have been made available for general distribution for domestic and other small users. The new pack contains two tubes, one of epoxy resin and the other of hardener. When mixed together in equal amounts these components provide a cold or warm setting adhesive that is capable of withstanding severe conditions of exposure, including boiling water and all common solvents. It can be used for bonding non-porous materials, such as metals, glass and most plastics.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—We have received from the Institution of Engineers and Shipbuilders in Scotland a copy of a paper entitled "Simplified Calculation of Longitudinal Bending Moments," by Professor A. Mandelli. The paper is divided into three parts. The first describes a method by which the exact value of the bending moment amidships for any condition of loading of a given ship can be calculated without resorting to bending moment curves. The second deals with the determination of the influence line of bending moment amidships and its practical applications. The third part gives a method by which basic calculations of Part 1 can also be used to determine the buoyancy curve when a complete bending moment curve is required. The paper is submitted for discussion in writing, which will close on November 26th, and those wishing to take part may obtain copies from the Institution at 39, Elmbank Crescent, Glasgow, C.2.

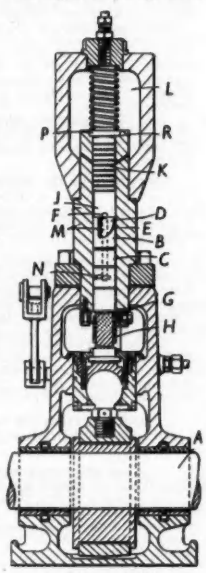
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

736,299. February 20, 1952.—A Fuel Pump System, William Doxford & Sons, Ltd., William Hamilton Purdie and Percy Jackson, all of the company's address, Pallion Yard, Sunderland.

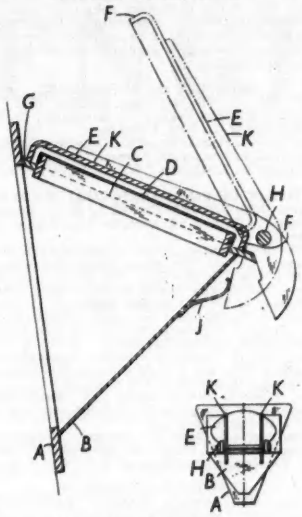
The invention relates to air-less injection internal combustion engines operating on the diesel or semi-diesel two-stroke cycles. Its object is to provide a reversible engine which does not require special reversing gear for the fuel-injection system and in which the timing of the beginning of fuel injection is adjustable. A further object is an arrangement which provides a smooth running fuel pump drive. In this example given the engine operates on the two-stroke full diesel cycle and has three operating cylinders. It is of the opposed piston reversing marine type. It has, for each cylinder, a fuel pump and accumulator unit. These units are all operated from a camshaft *A* which is common to all the cylinders and is driven from the engine at engine speed. All of the pump units are of the same construction. The pump plunger *B* is arranged to reciprocate in one end of a cylinder *C* by an eccentric on the camshaft and a connecting rod as shown. The plunger has at its upper end, a recess *D* in its circumferential face bounded, on one side, by a helical step *E*. The step co-operates with an inlet port *F* in the upper part of the cylinder wall to constitute the inlet valve. The port communicates with a pipe connection to a supply of fuel oil. The plunger can be rotated by a rack *G* engaging pinion teeth *H* cut in the lower end of the plunger. Movement of the rack determines the point in the upward motion of the plunger when the step *E* closes the port *F* and hence the quantity of fuel trapped in the space *J* in the cylinder above the plunger when the port is closed, this being the fuel pumped. In the cylinder above the space there is an upper plunger *K*—the accumulator plunger—of which the upper end extends into a chamber *L* containing oil or gas under pressure. A spring applies additional downward pressure to the plunger. The lower pump plunger *A* has an axial throughway *M* leading to a circumferential groove *N* which co-operates with a discharge port *N* in the cylinder wall, this port leading to a connection to the injection nozzle of the engine cylinder. In order to reduce the shock and noise which results when the collar *P* strikes the top of the cylinder, oil is trapped between the surfaces to act as a dashpot.—*September* 7, 1955.



No. 736,299

735,344. March 13, 1952.—Reducing the Effects of Crank Case Explosions, William Doxford and Sons, Ltd., William Hamilton Purdie, and Percy Jackson, all of the company's address, Pallion Yard, Sunderland.

The invention is concerned with means for reducing the effects of explosions of mixtures of air and oil sprays in the crank cases of large internal combustion engines. As the drawing shows, the crank case is substantially closed and extending outwards and upwards from an upright wall *A* of the crank case of the engine there is a short duct *B* of substantial cross-sectional area and having a circular pressure relief opening *C* at its upper end. Fitted over the opening to provide a substantially air-tight seal, there is a light disc *D* of plastic material, paper, card or other thin sheet material, preferably non-inflammable, the disc being flanged over the mouth of the duct as shown, and held by a garter spring around the mouth. Outside the disc there is a secondary closure member consisting of a metal cover *E* in the form of a disc with a dependent flange *F* which seats on a collar *G* around the mouth. The cover is hinged at *H* to the duct at one side of the mouth and is urged by its weight to the closed position. A buffer spring *J* limits the opening of the cover by engagement with extensions of ribs *K* on the cover and provides a further means tending to move the cover, when fully open, towards the closed position. The light inner disc *D* serves, in use, as a means for sealing the crank case against escape of oil spray and should there be an internal explosion



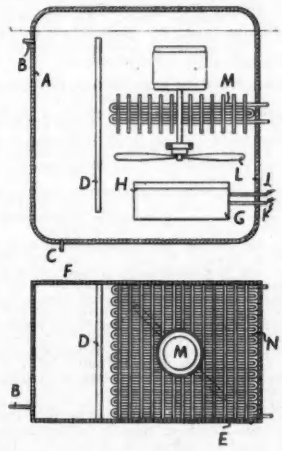
No. 735,344

the disc is ruptured or blown off the mouth of the duct. The pressure necessary to effect this result may be about 2 lb or 3 lb per square inch or less. At the same time the hinged secondary cover *E* is blown open. This cover is, however, rapidly returned to the closed position by its weight and the spring *J* and prevents the inrush of a large amount of air by the returning pressure wave. No claim is made to a crank case explosion relief structure as claimed in Specification No. 675,848.—*August* 17, 1955.

METAL PLATING

736,181. July 6, 1953.—Methods of and Apparatus for Coating with Metals, The Commonwealth Engineering Company of Ohio, 1771, Springfield Street, Dayton, Ohio, U.S.A.

The invention relates to the plating of metals from the gaseous state and the apparatus for carrying out the process. It is an object of the invention to provide a method for producing increased density deposits adaptable to discontinuous or continuous plating, The plating with decomposable metal bearing gas is characterised by keeping the gas temperature below the intergaseous decomposition point and directing the metal-bearing gases in agitated turbulent flow against the object to be plated. In the process, metal-bearing gases are heated to the decomposition temperature by heat radiating from the object being plated. The hot but undecomposed gases are recirculated through the system. Gas velocities and volumes maintained within the plating



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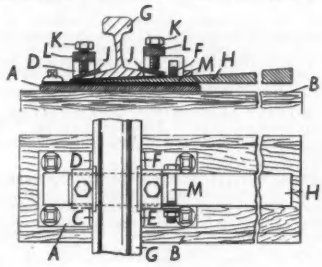
chamber quickly bring the hot gases into contact with a cooler, whereby a gas temperature in the range of 110 deg. to 175 deg. Fah., and preferably about 125 deg. Fah., is continuously maintained. To maintain the concentration of metal-bearing gases, fresh gases at a temperature of about 100 deg. Fah. are continuously or intermittently bled into the gases being recirculated in the chamber. Referring to the drawing, there is shown a housing *A* with a gas inlet *B* and a gas outlet *C*. Within the housing is a vertical panel *D* extending from the front to the back walls *E* and *F*. Positioned adjacent to the bottom of the housing is a heater *G* with a top plate *H* designed to heat metal objects placed on it to temperatures in the range of 350 deg. to 500 deg. Fah., preferably from 350 deg. to 450 deg. Fah. The heater *H* receives electric current through the cables, *J* and *K*. Above the top hot plate is suspended a fan *L* driven by an enclosed motor. This fan is designed to maintain gas velocities of from 40ft to 90ft per second. In the gas recirculation system is a gas cooler *M* receiving coolant from an external system. Two examples of operating procedure are included in the specification.—*September* 7, 1955.

RAILWAY ENGINEERING

736,916. June 4, 1953.—Adjusting the Height of a Rail, Gerard Krabbendam, Laan van Cattenbroeck 1, Zeist, Holland.

The invention relates to means for adjusting the height of a rail on a bearing member, such as a sleeper, by means of a wedge arranged between them. Referring to the drawing, the height-adjusting means has a base-plate *A* on the sleeper *B*. The base-plate has four uprights *C*, *D*, *E* and *F*, parts *C* and *D* situated at one side of the rail *G* and *E* and *F* at the other side. These protruding parts fix the flat bottom of the rail in the horizontal plane and at the same time form guides for the wedge *H* at right angles to the rail. The angle of the wedge is that which the upper face of the head of the rail makes with a horizontal plane on a horizontal or level part of



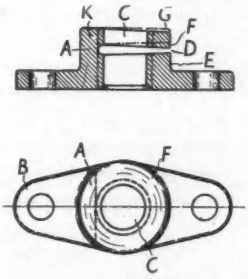
No. 736,916

the track. By driving the wedge further underneath the rail a loose sleeper becomes load-bearing without digging out the compressed ballast at the under side of the sleeper and applying an excess of fresh ballast. The connection of the rail *G* is by two clamping plates *J* bearing at one edge on the bottom of the rail and at the opposite edge on the wedge. These clamping plates are pressed down by means of two bolts *K* screwed into bridge-pieces *L*. The bridge-pieces *L* are connected with the upright parts. The wedge *H* is prevented from receding by a bolt *M* which passes through two slits in wings of the parts *E* and *F*, so that they are pressed towards the wedge to lock it. A modified arrangement of bridge-pieces is also shown in the specification.—*September* 14, 1955.

BEARINGS AND SUPPORTS

735,434. June 25, 1952.—Lock Nuts, Erik Waldemar Broden, 4, Heimdalsgatan, Linköping, Sweden.

The anchor or lock nut shown in the drawing comprises the body *A*, which by means of two integral lugs *B*, can be anchored to a base. Laterally running across the bore *C* of the nut is a slit *D*, which divides the body of the nut into a lower main body *E* and an upper locking piece *F*. During manufacture of the



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nut, when forming the slit, the locking piece is in the position *G* as shown in dotted lines in the upper view. The locking piece is then deformed to the position indicated by the full lines, so that the threads in the locking piece are out of line with the threads in the main body *E*. When a bolt is screwed into the anchor nut, the threads on the bolt force up the locking piece against the springing effect of the part *K* at the junction of the locking piece *F* to the position *G* in which position its threads are in line with those in the body of the nut. Consequently, the bolt is locked against unintentional rotation. In accordance with the invention, the lock nut is hardened to value greater than Brinell No. 250, preferably 325. Suitable steels are also mentioned in the specification.—*August* 24, 1955.

Launches and Trial Trips

HAMINEA, oil tanker ; built by Smith's Dock Company, Ltd., for Shell Tankers, Ltd.; length overall 557ft, length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,050 tons on 29ft 8¾in draught, service speed 14½ knots ; thirty-three cargo oil tanks, one main cargo pump room, four 400-tons-per-hour turbine-driven cargo pumps, and two stripping pumps, steam deck machinery ; two 550kW turbo-alternators and one 200kW diesel-driven alternator ; one set of Hawthorn Leslie double-reduction, two-casing, geared turbines, two Foster Wheeler "D" pattern boilers supply steam at 500 lb per square inch and 800 deg. Fah. Trial, September.

FLAMINIAN, cargo ship ; built by Henry Robb, Ltd., for Ellerman Lines Ltd. ; length between perpendiculars 325ft, breadth moulded 52ft, depth moulded to shelter deck 30ft, deadweight 3500 tons on 20ft 3in mean draught ; four holds, one 35-ton, two 15-ton and twelve 5-ton derricks, electric deck machinery ; three 180kW diesel-driven generators ; one Clark-Sulzer eight-cylinder, two stroke diesel engine, 3350 b.h.p. at 133 r.p.m.—Launch, October 4th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BELFAST ASSOCIATION OF ENGINEERS

Wed., Nov. 16th.—College of Technology, Belfast, "Fuel Oil Firing Equipment for Land Boiler Plant," D. A. Monk, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Nov. 9th.—N.E. SECTION : Neville Hall, Westgate Road, Newcastle upon Tyne, "Turret Tunes for Multi-Channel Television Reception," R. Holland, 6 p.m.——MERSEYSIDE SECTION : Chamber of Commerce, 1, Old Hall Street, Liverpool, 3, "The Dekatron Tube in a Digital Transmission System," G. Shand, 7 p.m.——W. MIDLANDS SECTION : Technical College, Wulfruna Street, Wolverhampton, "Closed Circuit Industrial Television," H. A. McGhee, 7.15 p.m.

Thurs., Nov. 10th.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Some Applications of Electronics to Marine Echo-Sounding," F. Baillie, 7 p.m.

CHADWICK PUBLIC LECTURE

Thurs., Nov. 17th.—Royal Society for the Promotion of Health, 90, Buckingham Palace Road, London, S.W.1, "The Centenary of London's Main Drainage System," J. Rawlinson, 5.30 p.m.

CHEMICAL SOCIETY

Thurs., Nov. 17th.—TILDEN LECTURE : Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7, "Some Developments in the Study of Physical Adsorption," D. H. Everett, 7.30 p.m.

DIESEL ENGINE USERS ASSOCIATION

Thurs., Nov. 17th.—Caxton Hall, Westminster, London, S.W.1, "Failures of Diesel Engine Valve Springs with particular reference to Fatigue," J. H. Darley, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 7th.—LEEDS CENTRE : Yorkshire Electricity Board, Ferensway, Hull, "Some Developments in Fluorescent Lighting," H. H. Ballin, 7 p.m.

Tues., Nov. 8th.—LONDON CENTRE : Lighting Service Bureau, 2, Savoy Hill, W.C.2, "Efficiency of Fluorescent Lamps," F. Jackson, R. Molloy and K. Scott, 6 p.m.

Wed., Nov. 9th.—NEWCASTLE CENTRE : Grey Hall, Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, 1, "The Architect's Approach to Artificial Lighting Design," G. Grenfell Baines, 6.15 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Nov. 8th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Power Without Smoke," and "Distinguished Company," films, 7.15 p.m.

Wed., Nov. 9th.—E. MIDLANDS BRANCH : County Hotel, Theatre Square, Nottingham, "Atomic Energy and the Future," J. A. Dixon, 7 p.m.

Thurs., Nov. 10th.—GLASGOW BRANCH : Scottish Building Centre, 425-427, Sauchiehall Street, Glasgow, "Modern Textile Drying Methods," K. S. Laurie, 7 p.m.——MERSEYSIDE AND N. WALES BRANCH : Royal Institution, Colquitt Street, Liverpool, "Steam for Process," L. G. Northcroft, 7.15 p.m.——N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Fuel Additives," E. G. Wood, 7 p.m.

Fri., Nov. 11th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, "Wire Ropes," N. B. Yates, 7.30 p.m.

Mon., Nov. 14th.—DUNDEE BRANCH : Mathers Hotel, Dundee, Discussion on "Fire Prevention," N. Hastie, 7.30 p.m.

Wed., Nov. 16th.—KENT BRANCH : Bull Hotel, Rochester, "Refrigeration and its Application," R. F. Brown, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 8th.—SLOUGH SECTION : Lecture Theatre, High Duty Alloys, Ltd., Slough, "Production of Moulds and Cores by the CO_2 Process," A. Talbot, 7.30 p.m.

Wed., Nov. 9th.—W. RIDING OF YORKSHIRE BRANCH : Technical College, Bradford, "CO_2 Process," A. Tipper, 7.30 p.m.

Thurs., Nov. 10th.—LINCOLNSHIRE BRANCH : Technical College, Lincoln, "Coreblowing," G. W. Fearfield, 7.15 p.m.

Tues., Nov. 15th.—COVENTRY AND DISTRICT SECTION : Room A5, Technical College, Coventry, "Hot Blast Cupolas," W. J. Driscoll, 7.30 p.m.——E. ANGLIAN SECTION : Public Library, Old Foundry Road Entrance, Ipswich, "Casting Defects," J. L. Francis, 7.30 p.m.

INSTITUTE OF FUEL

To-day, Nov. 4th.—S. WALES SECTION : Central Library, Alexandra Road, Swansea, "Electrical Hazards in Inflammable Atmospheres," G. D. Curtis, 6 p.m.

Wed., Nov. 9th.—LONDON SECTION : Institution of Civil Engineers, Great George Street, London, S.W.1, "Chimneys and the Dispersal of Smoke," J. E. Hawkins and G. Nonhebel, 5.30 p.m.——MIDLAND SECTION : Imperial Hotel, Temple Street, Birmingham, "The Work Entailed in Creating Smokeless Zones," Ronald Williams, 6 p.m.

Thurs., Nov. 10th.—SCOTTISH SECTION : North British Hotel, Edinburgh, Paper and Film on "The Production and Utilisation of Oil Fuel," 7 p.m.

Wed., Nov. 16th.—N.W. SECTION : Engineers' Club, Albert Square, Manchester, "The Effect of Coal Quality on the Efficiency of a Shell Boiler Equipped with a Travelling-Grate Stoker," E. J. Macdonald and M. V. Murray, 2.30 p.m.

INSTITUTE OF METALS

Tues., Nov. 8th.—Royal Institution, Albemarle Street, London, W.1, Symposium on "The Mechanism of Phase Transformations in Metals," 10 a.m. to 12.30 p.m., and 2.15 p.m. to 5 p.m. "The Shape of Grains in Single-Phase and Two-Phase Alloys," Cyril S. Smith, 8.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Nov. 9th.—26, Portland Place, London, W.1, "Preflame Reactions in a Diesel Engine," F. H. Garner, G. H. Grigg, F. Morton and W. D. Reid, 5.30 p.m.

Wed., Nov. 16th.—STANLOW BRANCH : Grosvenor Hotel, Chester, Refinery Utilities Symposium, "Steam," D. W. Smith ; "Electrical Power," W. S. Morris ; "Water," G. W. Power, 7.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Nov. 7th.—SCOTTISH CENTRE : North British Hotel, Edinburgh, "A Talk on Fibreglass for Road Transport," C. M. Johnson, 7.30 p.m.

Tues., Nov. 8th.—MIDLAND CENTRE : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Indivisible Loads," S. Bowskill, 7.30 p.m.——N. REGIONAL CENTRE : Victoria and Station Hotel, Preston, "Oxy-Acetylene Welding in the Automobile Industry," D. W. Wright, 7.30 p.m.——W. REGIONAL CENTRE : Adelphi Hotel, Lime Street, Liverpool, "Exhaust Braking and Automatic Chassis Lubrication," S. H. Edge, 7.30 p.m.

Wed., Nov. 9th.—E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "The Use of Light Alloys in Commercial Vehicle Construction," B. Bonallack, 7.30 p.m.

Fri., Nov. 11th.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "Tyres and Steering Geometry," J. H. Hardman, 7 p.m.

Mon., Nov. 14th.—E. REGIONAL CENTRE : Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "The Commer 'T.S.3' Two-Stroke Diesel Engine," E. W. Coy, 7.30 p.m.

INSTITUTE OF WELDING

To-day, Nov. 4th.—AUTUMN MEETING : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "The Welding of Nickel and High-Nickel Alloys by the Inert-Gas Shielded-Arc Welding Processes," J. Hinde and D. R. Thorneycroft ; "Inert-Gas Shielded Self-Adjusting Metal-Arc Welding of Copper and Copper Alloys," D. C. Moore and E. A. Taylor ; "A Methematical Examination of the Effect of Bounding Planes on the Temperature Distribution Due to Welding," Doris K. Roberts and A. A. Wells ; "Energy Distribution in Argon-Shielded Welding Arcs." J. F. Lancaster, 10 a.m. ; "The Testing and Inspection of Welds in Aluminium and Aluminium Alloy Plate," P. Bradley ; "Some Factors Affecting Design of Aluminium Alloy Fabrications Welded by the Inert-Gas-Shielded Metal-Arc Process," A. L. Hale : "Inert-Gas Arc Welding : Forward Trends in the Gas Turbine Industry," F. C. G. Sandiford, R. T. Weatherstone, O. J. Brown, K. H. McDowell and L. Camidge, 2.30 p.m.

Wed., Nov. 9th.—MEDWAY SECTION : Clarendon Hotel, Gravesend, "Recent Advances in the Welding of Aluminium Structures," J. E. Tomlinson, 7.45 p.m.

Thurs., Nov. 10th.—N. LONDON BRANCH : Manson House, Portland Place, W.1, "Automatic Argon Arc Welding of Low Alloy Steels," F. J. Wilkinson, 7 p.m.——S. LONDON BRANCH : 2, Savoy Hill, W.C.2, "Reclamation of Plant and Machinery by Welding," G. Gordon Musted, 6 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Nov. 9th.—MIDLANDS BRANCH : Midlands Institute, Birmingham, "Handling of Alcohols and Other Solvents," F. H. Walmsley, 6.30 p.m.

Fri., Nov. 11th.—GRADUATES' AND STUDENTS' SECTION : Caxton Hall, Westminster, London, S.W.1, "Air-Cooled Heat Exchangers," D. Kaye, 6.30 p.m.

Tues., Nov. 15th.—LONDON BRANCH : Geological Society, Burlington House, W.1, "An Assessment of Dry-Blending Equipment," F. E. Adams and A. G. Baker, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 8th.—PUBLIC HEALTH MEETING : Great George Street, Westminster, London, S.W.1, "The Development of Sewage Treatment in the City of Coventry," Granville Berry and C. R. Deeley, 5.30 p.m.

Tues., Nov. 15th.—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, "The Development of a Mechanical Draught Water-Cooling Tower," L. Gilling Smith and G. J. Williamson, 5.30 p.m.

Wed., Nov. 16th.—YORKSHIRE ASSOCIATION : General Lecture Theatre, The University, Leeds, "The Alt-na-Lairige Prestressed Concrete Dam," J. A. Banks, 7 p.m.——N.W. ASSOCIATION : 9, The Temple, 24, Dale Street, Liverpool, Address by the Chairman, J. D. T. Firth, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 7th.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Lagrange's Principle as the Basis of a Unified Treatment of the Action of Electrical Indicating Instruments," opened by D. Rutenburg, 6 p.m.——S. MIDLAND CENTRE : James Watt Memorial Institute, Birmingham, "The Electrification of the Manchester-Sheffield-Wath Lines," J. A. Broughall, 6 p.m.

Tues., Nov. 8th.—N. MIDLAND EDUCATION DISCUSSION CIRCLE : Central Electricity Authority, 1, Whitehall Road, Leeds, Discussion on "The Varying Methods of Educating Electrical Engineers," opened by H. J. Towse, 6.30 p.m.

Wed., Nov. 9th.—RADIO AND TELECOMMUNICATION SECTION : Savoy Place, London, W.C.2, "A Transistor Digital Fast Multiplier with Magneto-Strictive Storage," G. B. B. Chaplin, R. E. Hayes and A. R. Owens, 5.30 p.m.——N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, "Thermionic Valves of Improved Quality for Government and Industrial Purposes, E. G. Rowe, P. Welch and W. W. Wright, 7.30 p.m.

Thurs., Nov. 10th.—ORDINARY MEETING : Savoy Place, London, W.C.2, "Germanium and Silicon Power Rectifiers," T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell, 5.30 p.m.——N. SCOTLAND SUB-CENTRE : Electrical Engineering Department, Queen's College, Dundee, "Thermionic Valves of Improved Quality for Government and Industrial Purposes," E. G. Rowe, P. Welch and W. W. Wright, 7 p.m.

Mon., Nov. 14th.—INFORMAL MEETING : Discussion on "Is the Engineer Broad Enough in His Outlook ?" opened by P. Dunsheath, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Tues., Nov. 8th.—Bull Hotel, Rochester, Kent, "The Design and Application of Vee Belt Drives," J. Mitchell, 7 p.m.

Sat., Nov. 12th.—N.E. BRANCH : Visit to Lemington Glassworks, Ltd., Lemington-on-Tyne, 10.30 a.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., Nov. 8th.—LEEDS BRANCH : Theological Library, Church Institute, Albion Place, Leeds, 1, "The Reclamation by Impregnation of Porous Castings," P. J. Young, 7.30 p.m.——S.W. BRANCH : Grand Hotel, Broad Street, Bristol, Films, "Optical Jig Borers," and "Absolute Measurement," 7.30 p.m.

Wed., Nov. 9th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Quality Control During High-Speed Diesel Engine Manufacture," G. Bird, 6.45 p.m.

Mon., Nov. 14th.—WOLVERHAMPTON BRANCH : Compton Grange, Compton Road, Wolverhampton, "Heat Treatment of Steel," A. D. Hopkins, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Fri., Nov. 11th.—JOINT MEETING WITH ABERDEEN MECHANICAL SOCIETY : Robert Gordon's Technical College, Aberdeen "Fatigue Research at M.E.R.L.," C. E. Phillips, 7.45 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Wed., Nov. 9th.—SESSIONAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Symposium on "Corrosion," by D. G. Lewis, H. Campbell, P. Hamer and F. Wormwell, 5.30 p.m.

Thurs., Nov. 10th.—LIVERPOOL AND DISTRICT BRANCH : College of Buildings, Clarence Street, Liverpool, "Practical Hints on Embedded Panel Warming," F. Maguire, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Mon., Nov. 7th.—Institution of Civil Engineers, Great George Street, London, S.W.1, Photographic Exhibition of Roads, Bridges and Multi-Storey Garages, 5 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 4th.—GENERAL MEETING, HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Experiments on a Small Pump Suction Well, with Particular Reference to Vortex Formations," E. Markland and J. A. Pope ; "An Experimental Study of Air-Entraining Vortices in Pump Sumps," D. F. Denny, 5.30 p.m.

Tues., Nov. 8th.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, "Disk Brakes," F. G. Parnell and F. J. Bradbury, 5.30 p.m.——YORKSHIRE GRADUATES' SECTION : Chemistry Lecture Theatre, The University, Leeds, "Reinforced Plastics," E. N. Wilkinson, 7.30 p.m.

Thurs., Nov. 10th.—E. MIDLANDS GRADUATES' SECTION : Lecture Theatre, College of Technology, Loughborough, "Multi-Spindle Drilling," N. J. Beaumont, 7.15 p.m.——N.W. GRADUATES' SECTION : Engineers' Club, Albert Square, Manchester, "Instrumentation in the Chemical Industry," D. Buckley, 6.30 p.m.

Fri., Nov. 11th.—GENERAL MEETING, EDUCATION GROUP : 1, Birdcage Walk, London, S.W.1, "A Criticism of the Technical Education of Recently Qualified Engineers," P. P. Love, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Nov. 8th.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Economic Principles of Telecom's Plant Provision," N. V. Knight, 5 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Sat., Nov. 5th.—S.W. COUNTIES BRANCH : Duke of Cornwall Hotel, Plymouth, Chairman's Address, R. Hazzledine, 6.30 p.m.

Tues., Nov. 8th.—SCOTTISH BRANCH : Adelphi Hotel, Edinburgh, "Welded Plate Structures," James McLean, 6.15 p.m.

Wed., Nov. 9th.—LONDON GRADUATES' AND STUDENTS' SECTION : 11, Upper Belgrave Street, London, S.W.1, "Engineering in Architecture," G. I. Goulden, 6.30 p.m.

Sat., Nov. 12th.—WALES AND MONMOUTHSHIRE BRANCH : County Buildings, Colwyn Bay, "Recent Trends in the Design of Industrial Buildings," A. V. Hooker, 6 p.m.

INSTITUTION OF WORKS MANAGERS

Fri., Nov. 18th.—Waldorf Hotel, London, W.C.2, Annual General Meeting, 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 4th.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, 7 p.m.

Fri., Nov. 11th.—ORDINARY MEETING : Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Nuclear Research Installation at the Hammersmith Hospital," F. A. Smith, 7 p.m.

Mon., Nov. 14th.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, Sheffield, "Railway Locomotive Engineering," J. N. Compton, 7.30 p.m.——N.W. SECTION : Engineers' Club, Albert Square, Manchester, "Some Aspects of Mechanical Breakdown," C. G. Windeler, 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Nov. 4th.—Engineers' Club, Albert Square, Manchester, "The Management of Men," W. D. L. Greer, 6.45 p.m.

NATIONAL TECHNICAL GROUPS, ELECTRICAL POWER ENGINEERS' ASSOCIATION

Mon., Nov. 7th.—Tudor Room, Caxton Hall, London, S.W.1, "Quick Starting of Turbines," P. F. Carson, 7 p.m.

NEWCOMEN SOCIETY

Wed., Nov. 9th.—Science Museum, South Kensington, London, S.W.7, Annual General Meeting, "The Pre-Natal History of the Steamboat," H. Philip Spratt, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 11th.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "The Optimum Diameter of Marine Propellers : A New Design Approach," L. C. Burrill, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Nov. 8th.—SECTION LECTURE : The Library, 4, Hamilton Place, London, W.1, "High Aspect Ratio Wings," M. Hurel, 7 p.m.

Thurs., Nov. 10th.—MAIN LECTURE AT MERTHYR TYDFIL BRANCH : Teddington Restaurant, Teddington Aircraft Controls, Cefn Coed, Merthyr Tydfil, "Combustion," J. S. Clarke, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Nov. 14th.—ORDINARY GENERAL MEETING : 12, Great George Street, London, S.W.1, Presidential Address, W. R. Brackett, 5.30 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Nov. 8th.—B.I.S.R.A. Laboratories, Hoyle Street, Sheffield, 3, "Electric Arc Furnaces—Walls and Roof," A. H. B. Cross 7 p.m.

Tues., Nov. 15th.—B.I.S.R.A. Laboratories, Hoyle Street, Sheffield, 3, "Boiler Feed Water and Associated Corrosion Problems," J. Banks, 7 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Nov. 14th.—The University, St. George's Square, Sheffield, "The Value of Non-Destructive Testing," J. F. Hinsley, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Nov. 8th.—CHEMICAL ENGINEERING GROUP : Geological Society, Burlington House, London, W.1, Exhibition of Technical Films, 5.30 p.m.

SOCIETY OF ENGINEERS

Mon., Nov. 7th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Investigation into the Design of the Superstructure of a Power Station," C. W. E. Dudley, 5.30 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed., Nov. 9th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Symposium on "Corrosion," D. G. Lewis, H. Campbell, P. Hamer and F. Wormwell, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Nov. 10th.—LONDON BRANCH : Hope House, 45, Great Peter Street, Westminster, S.W.1, "Engineers in Management," B. E. Bosworth Munck, 7 p.m.